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ABSTRACT

Case studies of women in engineering education in institutions where women's enrollment kept pace with national trends in engineering or exceeded it are presented in this report. Societal forces and trends are reviewed, along with trends in enrollment, attrition, and degrees granted. The professional role of women in engineering is examined. Characteristics of men and women engineering students are compared. Case studies are presented of students from: (1) Vanderbilt University; (2) University of Washington; (3) Purdue University; (4) Colorado School of Mines; (5) Prairie View (Texas) A&M University; and (6) New Mexico State University. These are analyzed by both internal and external factors affecting enrollment, and projections are provided based on the analysis. Case study results are compared with trends found in national assessments. The future of women in engineering is also discussed. References are provided, as well as an annotated bibliography containing 29 entries. (JM)

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Women in Engineering:

An Exploratory Study of Enrollment Factors in the Seventies

March 1980

A Report Submitted to the National Institute of Education by the
National Center for Higher Education Management Systems
An Affirmative Action/Equal Opportunity Employer

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Women in Engineering:

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John G. Corbett
Suzanne Estler
William Johnston
Mary D. Ott
Harry Robinson
G. Roger Sell

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PREFACE

This study was performed by the National Center for Higher Education Management Systems pursuant to Contract No. 400-77-0004 with the National Institute of Education. However, the report does not necessarily reflect the view of that agency.

The authors include John G. Corbett of Boulder, Colorado, an independent researcher and visiting member of the faculty of Florida International University; Suzanne Estler, Assistant Professor of Higher Education at the University of Washington; Mary D. Ott of Silver Spring, Maryland, an independent researcher; Harry Robinson, Associate Dean for Academic Affairs and Director of Library Services at Bishop College and a Visiting Scholar at NCHEMS; and Senior Associate G. Roger Sell and Senior Staff Associate William Johnston of NCHEMS. Responsibility for the opinions and conclusions expressed in the report rests with NCHEMS staff.

We are indebted to large numbers of individuals at the six cooperating institutions who found time to be interviewed, to search files for information, and in numerous ways to facilitate the development of the case studies. Here it must suffice to acknowledge our particular appreciation for the cooperation and advice provided by Marty Nord, Director of the Women in Engineering Program, Vanderbilt University; William LeBold, Director of Engineering Education Research Studies, Purdue University; Michael Nyikos, Dean of Students, Colorado School of Mines; Austin Greaux, Dean of Engineering, Prairie View A & M University; and John Hernandez, Dean of Engineering, New Mexico State University.

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1. INTRODUCTION

A decade ago, fewer than 3,600 women were enrolled as full-time undergraduate students in the nation's 486 colleges and schools of engineering. They accounted for only 1.5 percent of total enrollment. By fall 1978, their numbers had risen above 34,000 and amounted to 11 percent of undergraduate enrollments. An estimated 16 percent of entering freshmen engineering students in fall 1979 were women. Between 1970 and 1978, women accounted for 39 percent of the total increase in full-time undergraduate engineering enrollments.

This study brings together all available national data on women in engineering in the 70s. In addition, it examines the experience of six institutions where enrollments of women have kept pace with the national trend or exceeded it. In an effort to account for the sharp rise in women enrollments, we examine influences external to the institutions as well as internal influences and responses, and we survey the perceptions and beliefs about causative factors expressed by knowledgeable individuals at the case-study institutions. Analysis of the case-study results and a comparison of these results with the national trends portrayed by data then form the basis for some conclusions and speculations about the prospects for women in engineering in the 1980s.

The increase in women students in engineering, their success as students, and the demand for women engineers in the work force may largely be explained in terms of societal forces. Changing attitudes about the roles of women combined with later marriages, lower birth rates, and governmental actions to secure equal opportunity for women in the world of work have encouraged more and more women to seek careers in the professions--in medicine, law, and dentistry, for example, as well as engineering. Employment trends in engineering have been particularly conducive to increased participation by women, both in engineering education and in the professional work force.

At present, recent women engineering graduates command slightly higher salaries than do their male classmates. In time, this advantage is lost, but the overall disparity in pay favoring men is not so pronounced as in many occupations. The disparity is at least partly accounted for by factors that appear to be nondiscriminatory.

Women tend to concentrate in chemical, industrial, and computer engineering programs and to avoid mechanical and electrical engineering. Sample data indicate that their academic performance and attrition rates are generally slightly better than that of men students--predictably so, in view of their similarly better performance in high school. Financial aid, counseling, and facilities appear to be available to women students on an equitable basis. Women are scarce on engineering faculties, but this absence of professional role models apparently does not constitute a major difficulty for women students.

The case studies in this report were conducted at Vanderbilt University, which actively began recruiting women engineering students in the 1960s and which now has perhaps the largest percentage of women students of any comparable institution; the University of Washington, where the enrollment of women reached 16.4 percent in fall 1979; Purdue University, which has more than 1,000 women students on campus; Colorado School of Mines, where women constituted 22 percent of the entering freshman class in fall 1979; Prairie View A & M, a predominantly black university with an expanding college of engineering in which women now account for nearly 27 percent of total enrollment; and New Mexico State University, where 14 percent of the engineering students are women, including a substantial representation of hispanic women and smaller representations of black and Native American women.

A comprehensive set of comparable data could not be obtained from the case-study institutions, but the similarity of their experiences suggests that the essential features have been duplicated in the experience of engineering schools generally. The case studies indicate that enrollment of women in engineering programs increased primarily because of external factors--strong employment prospects, industry recruitment of women, changed societal attitudes toward women's career roles, and the changed image of engineering as a profession. Secondary external factors include federal financial aid for students, affirmative action pressure on industry, encouragement from high-school teachers and counselors, and parental and family influence. Internal factors include the need on the part of institutions to reverse or forestall enrollment declines, persistent efforts to recruit women students, administrative support, favorable campus attitudes, and retention activities addressing the needs of women students.

When the experience of the case-study institutions is compared to national trends in the participation of women in engineering education in the 1970s, marked parallels are observed. While percentage participation varied across the institutions, the rates of increase from year to year were strikingly similar and closely tracked the national trend.

This again suggests the predominating influence of external factors on women's enrollments. The case studies indicate also that engineering schools are more responsive to shifts in societal attitudes and the needs of engineering employers than to legal mandates. Women seem chiefly drawn into engineering programs because (1) they now see engineering careers as relevant to social concerns that have traditionally interested women more than pure technology and, (2) because they perceive excellent prospect for employment in the engineering field of their choice at a good salary.

The study prompts four observations:

- As the proportion of women engineering students increases in the eighties, their competitive edge over men students will disappear and difficulties may develop for some women students that will require different or more intense support efforts
- Because employment trends have such strong impact on the demand for engineering education, any sizable downturn in the eighties could decimate gains made in women's participation over the past decade, especially if reductions in the engineering work force are accomplished on a first-in, first-out basis
- The rate of increase in women's enrollments in engineering schools in the seventies should not obscure the fact that the estimated 16 percent participation at present is less than one-third the level of participation of women in higher education generally
- Because engineering schools exhibit the tendency found in higher education generally to resist coercive and punitive

force, federal initiatives on behalf of women in engineering might better be patterned on the initiatives taken in recent years by engineering employers, including provision of funds to support the efforts of the engineering schools to attract and keep women students.

An annotated bibliography of literature bearing on women in engineering completes the report.

2. SOCIETAL FORCES AND TRENDS

Changing Roles of Women

Since the mid 1960s, the major agents of change affecting the roles of women in American society have been careerism among those in college, later marriages, sharply declining birthrates, and higher labor-force participation among married women and among mothers of young children (Chafe 1976, pp. 24-26). Later marriages and reduced numbers of children have freed women to engage in work outside of the home for longer periods of time. As a consequence, women's worklife outside the home is now expected to average only about a decade less than that of men (Kreps and Leaper 1976, p. 68). However, the situation for women professionals may differ somewhat from that for other women. For one thing, part-time, part-year jobs are harder to find in traditionally male fields than in areas traditional to women, such as the finance and service industries. On the other hand, financial rewards for professional employment may be sufficient to allow professional women to employ domestic help, including child care. Together, these factors are likely to encourage a very high proportion of women in the professions to work full time all year.

In the 1970s, women attending college in ever-increasing numbers, both as full-time undergraduate and graduate students and as returning students. Many, although not the majority, pursued nontraditional programs for women, such as medicine, law, dentistry (Ott 1976) and engineering. Reasons for the increases in these nontraditional enrollments include:

- A reduction or elimination of discrimination against women applicants (Westervelt 1975)

- An increase in the visibility of women in the professions
- Increased interest in a career among women college students (Chafe, p. 26)
- Decreased opportunities for careers in the traditional field of education

In engineering, other forces were also at work. Engineering schools encountered a reduction in male applications in the early 1970s, partly because of a well-publicized decline in employment in the aerospace industry. At the same time, government agencies began to pressure industry to increase the employment of women and minorities. This pressure prompted industrial support for programs to attract women and minorities to engineering. In addition, members of the Society of Women Engineers (SWE) worked to increase the interest of women students in engineering, both in the high schools and in the colleges.

Role of the Federal Government

Federal laws and policies have both reflected and promoted changes in women's roles. In July 1962, two years prior to the Civil Rights Act, President Kennedy issued an order requiring federal employees to be hired and promoted without regard to sex. In July 1963, the Equal Pay Act was passed. In July 1964, Title VII of the Civil Rights Act of 1964 prohibited discrimination in employment because of sex, race, color, religion, and national origin. In October 1967, Executive Order 11246, which prohibited discrimination by federal contractors, was amended to cover sex discrimination. In March 1972, the Equal Employment Opportunity Act, including the requirement of equal fringe benefits for men and women was passed. In June 1972, Title IX of the Education Amendments of 1972 prohibited sex discrimination in most federally assisted education programs. At the same time, the Equal Pay Act was extended to include administrative, professional, and executive employees. Another source and evidence of changed attitudes was the 1973 decision of the U.S. Supreme Court on abortions.

Status of Women in Higher Education

The enrollment of women students in higher education has increased greatly in recent years, particularly among reentry women of age 25 and older. Women now constitute about 50 percent of first-year graduate and professional students (Gappa and Uehling 1979, p. 11). The increase in women enrollments has been especially marked in the professional schools, such as medicine, dentistry, law, and veterinary medicine (Ott 1976). The popularity of nontraditional fields for women, such as business and agriculture, has increased, while their enrollments in such traditional fields as education, English, fine arts, and humanities has declined to some extent (Gappa and Uehling, pp. 12-13). As this report will document, a striking increase has occurred in the enrollment of women in bachelor's-degree programs in engineering.

About 25 percent of all faculty in higher education are women. But they are not equally distributed among institutions or programs. They are more likely to work in the less prestigious institutions and also in two-year and four-year colleges, where teaching rather than research is emphasized. Women tend to teach art, drama and music, foreign languages, health, and English, rather than economics, law, physics, and agriculture. Women also tend to be clustered in the lower, nontenured ranks (Gappa and Uehling 1979, pp. 41-42).

Women administrators similarly are concentrated in the lower levels, and their numbers are increasing in these lower-level positions. Women are not typically found in academic administrative positions in part because candidacy for these positions often is restricted to faculty and department chairmen. However, women hold slightly over half of the administrative positions at women's colleges (Gappa and Uehling, pp. 46-47).

Employment of Women in the Professions

Women have steadily increased their representation in the professions over the past decade. According to Norwood and Waldman (1979, p. 3), the proportion of women increased between 1970 and 1978 among accountants (25.3 percent to 30.1 percent), engineers (1.6 percent to 2.8 percent), lawyers and judges (4.7 percent to 9.4 percent), physicians and osteopaths (8.9 percent to 11.3 percent), and college and university teachers (28.3 percent to 33.8 percent). Science Manpower Commission data indicate that about 14 percent of the nation's scientists and engineers are women, and that 10 percent of those holding the doctorate are women (Vetter 1980, p. 28).

In the professions, as in most areas of employment, men's salaries exceed those paid women. In 1977, for example, the median earnings of male accountants stood at $17,312, or 55 percent higher than the $11,155 median for women accountants; among college and university faculty, the median for men was $20,337, 34 percent higher than the women's median of $15,172. In engineering in 1977, the median for men was $23,200, 27 percent above the women's median salary of $18,200 (Women's Bureau 1979). In 1978, the median salary of men who had earned the bachelor's degree in engineering in 1976 was $17,210, only 6.4 percent higher than the median salary of their women classmates (Vetter 1980, p. 32). (As we will see, however, the disparity is likely to increase with time.)

3. THE PROFESSIONAL ROLE OF WOMEN IN ENGINEERING

Employment Patterns over the Past Decade

The Society of Women Engineers conducted surveys of its membership in 1972 (Kistiakowsky), in 1974 (SWE 1975), and in 1977 (SWE 1978). Table 1 shows the percentages of women engineers by type of employer in those years. (Note that the number of respondents in 1977 was three times as large as in 1972, reflecting a growing influx of women into engineering). Private industry and business employed about two-thirds of the survey respondents in this period. The federal government and colleges and universities also employed substantial numbers of women engineers. The reduction in 1977 of the proportion of women who were self-employed probably reflects the decreasing mean age of the respondents, since self-employment is most common among more senior engineers.

Of 12 job functions, the one most frequently chosen to describe the respondents' engineering employment was design, followed by analysis, development, research, and administration, in varying orders each year. Sales and service and construction were chosen least frequently. The proportions of respondents with supervisory responsibility decreased from 40 percent in 1972 and 1974 to 34 percent in 1977, again probably reflecting the influx of recent graduates.

The fields of employment of the women responding to the SWE survey differed in 1972, 1974, and 1977. In 1972 and 1974, the most common field was aerospace engineering. By 1977, this field was in seventh place among all fields, in part reflecting an overall decline in aerospace employment. Chemical engineering and civil engineering

Table 1

Percent of Women Engineers by Type of Employer

Type of Employer	1972[a] (N=346)	1974[b] (N=418)	1977[c] (N=1037)
Private industry or business	62%	63%	67%
Utilities (1977 survey only)			8%
Federal government civilian employee	14%	11%	7%
College or university	10%	10%	7%
Self-employed	4%	5%	2%
Non-profit organization other than a school	2%	3%	2%
State government	3%	3%	2%
Military service or USPHS-active duty	2%	1%	1%
Local government	1%	1%	1%
Junior college or technical institute	1%	0.5%	0.5%
Secondary, elementary or other school	0.3%	0.5%	0.2%
Other	3%	2%	2%

[a] Source: Kistiakowsky, Note 2, p. 12.
[b] Source: Society of Women Engineers 1975.
[c] Source: Society of Women Engineers 1978.

were the top two fields in 1977, although they had been fifth or lower in 1972 and 1974.

Thus the changes in the placement of women engineers from 1972 through 1977, as reflected in the SWE survey results, included:

- A reduction in the proportion who were self-employed
- A reduction in the proportion with supervisory responsibility
- A decrease in aerospace employment, and an increase in employment in chemical and civil engineering

The employment of women engineers in colleges and universities increased by 15 percent from 1974 to 1978, while the number of men increased only 2 percent. Nevertheless, only 2.5 percent of the engineers now working in academic institutions are women. Furthermore, a high proportion of women scientists and engineers in colleges and universities hold nonfaculty, nontenure track appointments (National Science Foundation 1979a).

Comparative Positions and Salaries of Women in Engineering

Women in engineering currently command slightly higher salaries at college graduation than do men in engineering (Babco 1979). However, among experienced engineers, the reverse is true. As we have noted, the median salary of women engineers in 1976 was $18,200, whereas the median for men was $23,200. This difference might be explained in terms of amount of work experience since earning the bachelor's degree. At all levels of experience, however, women nonsupervisory scientists and engineers reported lower salaries than men did (Babco 1979). Among engineers with doctorates, the median annual salary in 1977 for men was $28,700. For women it was $22,900 (Babco 1979).

There are several possible causative factors for those differences in salary. A 1975 survey of the membership of the Institute of Electrical and Electronics Engineers (IEEE) sheds some light on the discrepancy between initial salaries and salaries of experienced engineers. The survey respondents included 224 women and 43,091 men. Twenty-five percent of the women members felt that they had been discriminated against in hiring, and 31 percent felt they were discriminated against in promotion. The mean salary of the women was more than $4,000 below that of the males ($23,715 vs. $19,697). This difference was not a result of a difference in the age distributions of men and women IEEE members. Men and women who were new in engineering received roughly the same salaries. As experience increased, however, men's salaries became progressively larger than women's. One possible explanation is that women were not being promoted beyond a certain level ("EE Minorities and Discrimination" 1975).

A major source of information on experienced engineers--those in the profession at least since 1970--is a survey covering a sample of both scientists and engineers, conducted in 1978 by the Census Bureau for the National Science Foundation (NSF 1979b). Women were only 0.4 percent of the estimated population of experienced engineers (2,445 out of 621,317). Women and men differed in highest professional degree attained, proportions employed full-time, type of employer, primary work activity, and salaries:

- A larger proportion of the women than of the men held degrees beyond the bachelor's level (41 percent of the women; 27 percent of the men)

- Of those engineers who were employed, 88 percent of the women and 96 percent of the men were employed in science or engineering
- Ninety-two percent of the employed women worked full time, as did 98 percent of the men
- Of those who were employed, 75 percent of the men and 61 percent of the women worked for business and industry, 16 percent of the men and 29 percent of the women worked for a local, state, or federal agency, and about 5 percent of each group worked for educational institutions
- The primary work for 35 percent of the men and 20 percent of the women was management or administration, whereas 17 percent of the women and 5 percent of the men were engaged in report writing, statistical work, or computer applications
- The 1978 median annual salaries of full-time workers were $27,400 for men and $24,100 for women; among those aged 30 to 34, the median was $24,100 for men and $22,400 for women; among those whose highest degree was a bachelor's degree, the median salaries were $26,900 for men and $24,000 for women

Thus among experienced engineers, women are less likely than men to work in science and engineering, work full time, work for business and industry, or be in management and administration. These differences in type of work may partly account for the lower salaries paid women.

The results of a survey by the Society of Women Engineers in 1977 of women holding a professional engineer (PE) license can be usefully compared to a survey conducted in the same year of the membership of the National Society of Professional Engineers (NSPE). (The NSPE membership includes a small number of women, but their responses were not reported separately. Seventy-one percent of the SWE respondents were also members of one or more other professional societies.) Twelve percent of SWE respondents held a PE license (128 women); 50 percent of these held a graduate degree. Their average age was 43. Slightly more than half were in civil, mechanical, or electrical engineering. Their average income for 1977 was $23,212 (Society of Women Engineers 1978). Twenty-nine percent of the NSPE respondents held graduate degrees, usually the master's degree. Median time in the profession was 17 years. Over 75 percent worked in civil, mechanical, or electrical engineering. Among the NSPE respondents, the median income was $26,780 (National Society of Professional Engineers 1978).

Thus the subsample of SWE members who were professional engineers was older than the NSPE sample, worked in a larger variety of engineering fields, had more graduate education, but apparently lower incomes. One reason for the lower salaries may be the lower proportion of self-employed engineers among the SWE respondents. Among NSPE members, median earnings of self-employed members (14 percent of the respondents) were almost $12,000 higher than those of salaried engineers. Only 2 percent of all SWE respondents were self-employed, although the proportion of SWE Professional Engineers who were self-employed was probably somewhat greater than that.

The most comprehensive study of relative salaries available concentrated on engineers employed by the federal government. About 1 percent are women. In October 1977, the mean salary of male Civil Service engineers was about $6,000 (31 percent) higher than the mean salary for their women counterparts. A regression analysis reduced the difference to 9 percent, by taking into account differences in occupation, minority-group status, education level, Civil Service tenure status, geographic area of employment, primary work activity, age of employee, and length of federal service. The remaining unexplained salary differential may reflect the effect of such factors as job conditions or discriminatory practices (National Science Foundation 1979c).

To sum up, possible reasons for the fact that women engineers generally earn less than their male colleagues include:

- Women may not be promoted beyond a certain level
- Men and women may work in different areas of engineering
- Fewer women than men may be self-employed
- In the federal Civil Service, there may be differences in occupation, minority-group status, education level, tenure status, geographic area of employment, primary work activity, age of employee, and length of service

4. TRENDS IN ENROLLMENT, ATTRITION, AND DEGREES GRANTED

Undergraduate Enrollment Trends

The enrollment of women in bachelor's-degree programs in engineering totaled 3,569 in fall 1970, or 1.5 percent of the total undergraduate enrollment of 231,730 students; by fall 1978, there were 34,518 women in undergraduate engineering programs, or 11.0 percent of the total enrollment of 311,237 (table 2).[1] Thus women accounted for 39 percent of the increase in full-time undergraduate engineering enrollments that occurred between 1970 and 1978. The overall increase during those years amounted to 34 percent, but only 21 percent for men. (In fall 1979, total full-time enrollment rose to 340,488, a one-year increase of 9 percent that put the growth for the decade at nearly 47 percent (Engineering Manpower Commission 1980). Data on fall 79 enrollment by sex were not available at this writing.

Table 3 shows percentages of women enrolled in the seven largest engineering fields. Chemical, industrial, and computer engineering were most popular with women; mechanical and electrical engineering were least popular. (No information is available about enrollments of women by type of institution.)

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[1] Over the period 1970-78, the proportion of undergraduate women in engineering attending part time varied from 3.9 to 5.4 percent. For all part-time students, the range was 6.7 to 8.2 percent. Information usefully distinguishing between full-time and part-time women students in engineering with respect to preparation, program choice, academic performance, placement, and work experience is largely unavailable. Therefore this report concentrates on data relative to full-time students.

Table 2

Undergraduate Full-time Enrollments in Engineering

(Fall Quarter 1970-1978)

Year	Number Men	Number Women	Annual Increment in # of Women	Total Undergrads	% Women	Annual Increment % Women
1970	228,161	3,569		231,730	1.5	
1971	206,842	3,983	414	210,825	1.9	.4
1972	190,240	4,487	504	194,727	2.3	.4
1973	180,641	6,064	1,577	186,705	3.2	.9
1974	191,271	9,828	3,764	201,099	4.9	1.7
1975	215,527	15,852	6,024	231,379	6.8	1.9
1976	235,899	21,936	6,084	257,835	8.5	1.7
1977	260,475	28,773	6,837	289,248	9.9	1.4
1978	276,719	34,518	5,745	311,237	11.0	1.1

Source: Engineering Manpower Commission of Engineering Joint Council [annual editions] 1970-1978.

Table 3

Full-time Engineering Enrollments in Seven Fields

Fall 1977 and Fall 1978

Curriculum	Fall 1977			Fall 1978		
	Women	Total	% Women	Women	Total	% Women
Chemical	4,842	26,471	18.3%	5,800	29,844	19.4%
Industrial	1,466	9,142	16.0%	1,947	10,184	19.1%
Computer	1,093	6,908	15.8%	1,447	8,632	16.8%
General	6,373	52,684	12.1%	7,222	52,461	13.8%
Civil	4,085	42,981	9.5%	4,584	44,162	10.4%
Mechanical	2,910	47,314	6.2%	3,811	52,949	7.2%
Electrical	3,280	59,226	5.5%	4,213	64,524	6.5%
All Curricula	28,773	289,248	9.9%	34,518	311,237	11.1%

Source: Engineering Manpower Commission of Engineers
Joint Council 1977, 1978.

As table 4 shows, first-year enrollment of women increased over the decade at a rate slightly higher than the total enrollment of women; for example, women accounted for 11 percent of total enrollment in fall 78 and 12.3 percent of first-year enrollment. (If one follows an entering class through successive years on table 4, a large drop will be encountered in the second year, followed by moderate increases in the third and fourth years. Presumably this is accounted for by students transferring from other programs and reentry students.)

Attrition Rates and Transfers

There is little direct information available on national attrition rates, except for the retention rates reported by Ott (1978b), which are discussed later in this report. From year-by-year data on enrollments of bachelor-degree students in engineering, one can infer certain attrition trends. However, the proportion of original entrants who are retained cannot be inferred, because individuals enter as well as leave the engineering-student population.

Once again, we refer to table 4 for enrollment data by class year. Beginning in 1973, when complete data were first reported for women, one can work down the tables diagonally from left to right to follow the year-by-year changes in enrollments for each entering class. Two general conclusions concerning attrition can be drawn from these figures.

First, there were net decreases in the total numbers of students and in both the numbers and percentages of women enrolled between fall of freshman year and fall of sophomore year. For women, substantial decreases between freshman and sophomore years began with the fall 1975

Table 4

Undergraduate Full-time Enrollments in Engineering by Class Year

Bachelor's Degree Level
Fall Quarter, 1970-1978

	1st Year			2nd Year			3rd Year			4th Year			5th Year		
Year	Total	# Women	% Women	Total	# Women	% Women	Total	# Women	% Women	Total	# Women	% Women	Total	# Women	% Women
1970[a]	71,661	1,457	2.0	53,419	817	1.5	49,855	598	1.2	51,983	483	.9	4,812	39	0.8
1971[a]	58,566	1,541	2.6	47,948	964	2.0	48,543	725	1.4	51,377	524	1.0	4,391	59	1.3
1972[a]	52,100	1,542	3.0	42,272	1,119	2.6	45,874	970	2.1	49,895	733	1.5	4,586	69	1.5
1973	51,925	2,417	4.7	40,519	1,487	3.7	41,673	1,140	2.7	48,366	1,020[b]	2.1	4,222	b	
1974	63,444	4,266	6.7	45,935	2,476	5.4	43,007	1,724	4.0	44,538	1,362[b]	3.0	4,175	b	
1975	75,343	6,730	8.9	55,891	4,197	7.5	49,338	2,862	5.8	47,070	2,063[b]	4.3	3,737	b	
1976	82,250	8,545	10.3	63,003	5,848	9.3	56,835	4,407	7.7	51,692	3,136[b]	6.0	4,055	b	
1977	88,780	9,921	11.1	70,326	7,537	10.7	64,721	6,193	9.6	60,109	4,813	8.0	5,312	309	5.8
1978	95,805	11,789	12.3	72,150	8,447	11.7	69,816	7,453	10.6	68,260	6,402	9.3	5,206	427	8.2

Source: Engineering Manpower Commission of Engineers Joint Council [annual editions], 1970-1978.

a. Totals for years prior to 1973 include only those actually reported; totals underrepresent the actual numbers of women.

b. Figures for fourth-year enrollments from 1973 to 1976 include fifth year numbers.

entering class. The net decreases for women in the sophomore classes were from 12 percent to 15 percent for each subsequent entering class. Total enrollments of men and women declined between freshman and sophomore year every year from 1973 onward, with decreases of 12 percent for the 1973 and 1974 entrants, and 14 percent to 18 percent for 1975 to 1977 entrants. Thus the rate of net decrease in students between freshman and sophomore years was somewhat greater for men than for women over the years 1973 to 1977.

Second, there were net increases in the numbers of total students and in the numbers of women students as each entering class progressed beyond sophomore year. (The one exception was a reported decline in enrollments between second-year enrollments in fall 1977 and third-year enrollments in fall 1978. This apparent decline might be due to the fact that a smaller number of schools reported enrollments in 1978 than in 1977.) Apparently there was a greater rate of transfer or re-entry into engineering programs than of attrition from these programs, starting in the junior year. The rate of transfer into engineering programs appears larger for women than for men.

Bachelor's Degrees Awarded to Women

According to data from the National Center for Education Statistics (1970 through 1978 annual editions), women received 0.8 percent of the bachelor-level engineering degrees in 1970-71, and 7.4 percent of the degrees in 1977-78 (table 5). The only available degree data by type of institution combine degrees in engineering and engineering technologies. As shown in table 6, a majority of both men and women in engineering and engineering technologies graduate from public institutions.

Table 5

Men's and Women's Bachelor's Degrees in Engineering,

1970-71 through 1977-78

Year	Degrees to Men	Degrees to Women	% of Degrees to Women
1970-71	44,848	361	0.8%
1971-72	45,201	492	1.1%
1972-73	46,183	527[a]	1.1%
1973-74	42,540	697	1.6%
1974-75	38,961	845	2.1%
1975-76	37,457	1,317	3.4%
1976-77	39,285	2,044	4.9%
1977-78	43,743	3,479	7.4%

Source: National Center for Education Statistics [annual editions] 1975-1978.

Note: Totals exclude degrees in engineering technologies.

a. Corrected total.

Table 6

Bachelor's Degrees in Engineering and Engineering Technologies in Private and Public Institutions

	1970-71		1971-72		1972-73		1973-74		1974-75		1975-76		1976-77		1977-78	
Year	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
All Schools	49,954	403	50,927	538	50,985	628	49,891	802	46,266	1,037	45,235	1,482	47,437	2,240	52,284	3,725
Public	35,170	255	35,930	373	35,799	452	35,706	554	33,302	707	32,714	1,029	34,664	1,523	38,382	2,541
Private	14,784	148	14,997	165	15,186	176	14,185	248	12,964	330	12,521	453	12,773	717	13,902	1,184
% Public	70.4	63.3	70.6	69.3	70.2	72.0	71.6	69.1	72.0	68.2	72.3	69.4	73.1	68.0	73.4	68.2
% Private	29.6	36.7	29.4	30.7	29.8	28.0	28.4	30.9	28.0	31.8	27.7	30.6	26.9	32.0	26.6	31.8

Source: National Center for Education Statistics
[annual editions] 1975-1978.

However, in all years except 1972-73, a larger proportion of the women than of the men graduated from private institutions. This trend differs from that among all bachelor-degree recipients.

5. CHARACTERISTICS OF WOMEN AND MEN ENGINEERING STUDENTS

Ott's survey of a nationwide sample of male and female students who entered engineering as freshmen in fall 1975 or fall 1976 (Ott 1978d) provides the most comprehensive information available concerning the characteristics of women engineering students. The study population included all 41 colleges and universities that enrolled 30 or more freshman women in bachelor-degree programs in fall 1975, and one predominantly black institution. The survey sample included 16 of these 42 schools. The results of the surveys are generalizable to the 42 schools in the survey population. These are primarily universities, rather than two-year or four-year colleges. (Except where otherwise noted, this section draws on Ott 1978a.)

Academic Background

Women engineering students were superior students in high school. Some 38 percent of the women freshman had been in the top 2 percent of their high-school classes, as were about 19 percent of the men. Seventy percent of the women freshmen and 50 percent of the men obtained A averages in high school.

Forty-two percent of the fall 1976 survey population reported scores on the American College Testing Program (ACT) examination for the mathematics subtest, the natural-science subtest, and the composite score. In the engineering survey population, men had slightly higher scores than women did on the natural-science subtest but essentially the same scores on the mathematics subtest and on the composite score.

As shown in table 7, scores of men and women in the engineering-survey population were more similar than were scores of all men and women who took the ACT.

Seventy-two percent of fall 1976 engineering freshmen reported Scholastic Aptitude Test (SAT) mathematics and verbal scores. In the engineering population, women tended to have somewhat higher scores on the verbal SAT than men did, although this was not true for the total group of high-school seniors who took the SAT (table 8). The median score for men in engineering was in the range from 540 to 560; the median score for women in engineering was in the range from 570 to 590; the median score for all high-school seniors was in the range of 400 to 450. For the math SAT, the median score for men in engineering was in the range 660 to 680. That for women engineers was in the range 630 to 650. In contrast, the difference in median scores for all high-school senior men and women who took the test was 60 points (500 for men, 440 for women). Similar SAT results were reported by Davis (1977).

Although the actual number of mathematics courses taken in high school is not known, men's and women's attitudes to math appear to differ. Forty-nine percent of the women and about 35 percent of the men reported that mathematics was their favorite subject in high school.

Academic and Career Expectations

Throughout the freshman and sophomore year, larger proportions of men (20 percent) than of women (about 10 percent) planned to major in electrical engineering. More men than women expected to rank in

Table 7

Distributions of ACT Scores

(Percentage)

Standard Score	1975-76 Students		Fall 1976 Engineering Population	
	Men	Women	Men	Women
Mathematics Subtest				
31 to 36	5	1	34	34
25 to 30	27	16	54	54
19 to 24	22	19	11	11
Below 19	46	64	1	2
Natural Science Subtest				
31 to 36	11	4	42	38
25 to 30	28	21	40	39
19 to 24	28	30	17	19
Below 19	33	45	1	4
Composite Score				
31 to 36	1	1	16	19
25 to 30	20	13	59	54
19 to 24	33	27	23	25
Below 19	45	59	2	2

Source: Ott 1978a.

Note: These figures are based on a 10 percent sample of all high-school students tested in 1975-76 (American College Testing n.d.) and on the data for the 42 percent of men and women in the engineering survey population who reported scores.

Table 8

Distributions of SAT Scores

(Percentage)

Standard Score	1975-76 High-School Seniors		Fall 1976 Engineering Population	
	Men	Women	Men	Women
Mathematics				
750 or above	2.0	0.3	16	11
600 to 740	21	10	69	68
Below 600	77	90	15	21
Verbal				
750 or above	0.3	0.2	1	2
600 to 740	8	8	35	42
Below 600	92	92	64	56

Source: Ott 1978a.

Note: These figures are based on scores of high-school seniors of the class of 1976 (Admissions Testing Program of the College Entrance Examination Board 1976) and on the data for the 72 percent of the students in the engineering survey who reported SAT scores.

the top 10 percent of their freshman class and to obtain an A average, despite the women's superior records in high school.

About 62 percent of the women and 47 percent of the man planned to start full-time professional work as early as ages 21 to 23. Larger proportions of men than of women wanted to start part-time work between 21 and 23 years of age. A larger proportion of women than of men were interested in starting part-time work from 30 to 32 years of age.

Women indicated more interest than men in stopping work between the ages of 24 to 29. About 88 percent of the women who wanted to stop working for longer than six months between these ages were interested in having a child during that period (Ott 1978c).

Financial Aid

Information about sources of financial aid for men and women engineering students is sparse. The survey of fall 1975 engineering freshmen asked students what was their main source of financial support. The only significant difference was that 9 percent of men and 5 percent of women said that their main source of support was "previous personal earnings and savings." Forty-six percent of both men and women received scholarships. However, 71 percent of the women and 66 percent of the men did not expect to be employed during college (Ott 1977).

Attrition Rate

The only analysis of the retention characteristics of a large population of engineering students having a substantial proportion of women was reported by Ott (1978b). Women constituted an estimated 15 percent of the fall 1975 freshman population of 19,300 engineering students at 42 schools. Retention was determined 1 1/2 years after college entrance for a sample of students at 16 schools in the population. There were 1,637 men and 1,276 women in the sample.

Students were considered retained if they registered in engineering as freshmen in fall 1975 and remained at the same school in engineering throughout the spring 1976 term and the early part of the spring 1977 term (1 1/2 years). The estimated proportions retained at all 42 schools in the population at the start of the spring term of the sophomore year were 73.3 percent for men, and 67.8 percent for women. These estimated proportions are meaningfully different at the .01 level of significance. Retention rates were lower for women than for men at 13 of the 16 schools in the sample. Retention rates were lower for men than women at two schools, and equal for men and women at one school. This difference in the number of schools having higher retention rates for women and those having higher rates for men is significant at the .05 level (sign test).

Ott's retention study included the students who had completed freshman surveys in fall 1975. These survey responses allow a comparison of the characteristics of the students who were more or less likely to be retained in engineering. Survey responses more characteristic of men who were retained than of other men were as follows:

- Academic achievement in high school (90 to 97 percentile of class; A average

- Self-confidence in regard to future academic performance
- Graduation from a public high school
- College attendance quite or extremely important to parents
- Mathematics as favorite high-school subject
- Considered fewer than four fields for college major
- Interest in attending graduate school to increase earnings
- Stable, secure future as a major source of job satisfaction

Items more characteristic of women who were retained than of other women included:

- Academic achievement in high school (A average; 90th percentile or above)
- Father a college graduate
- Caucasian race
- College attendance extremely important to parents
- Two or more hours of homework per day in high school
- Selected major from two fields
- Plan to be married, have children, and work part-time 10 years from time of survey
- Working with ideas as major source of job satisfaction

Another way of determining the reasons for attrition from engineering is to look at the destinations of the students who left. Among the students who completed the fall 1975 survey, 176 men and 200 women were not retained in engineering at their original schools in spring 1977. Destinations were obtained for 77 percent of these men and women and proved to be quite different (see table 9). A majority of

Table 9

Reported Destinations of Survey Respondents Who Were Not Retained

(Percentage)

Destination	% Men (n = 136)	% Women (n = 155)
1. Temporary leave of absence	5	3
2. External transfer--engineering	3	2
3. External transfer--other	7	8
4. Internal transfer	43	68
5. Academic failure	24	10
6. Leaving without academic failure	18	10

Source: Ott 1978a.

the women students not retained were internal transfers. Academic failure and dismissal directly accounted for the departure of a larger percentage of the men than of the women. Thus the difference in retention rates for men and women engineering students in Ott's population was apparently the result of higher rates of internal transfer for women than for men.

Grade Point Averages

As we have noted, women engineering students had been superior students in high school. At college entrance, however, men expressed greater levels of self-confidence in the grades they expected as freshmen in engineering and in their expected performance, particularly relative to women students. At the end of the freshman year, furthermore, larger proportions of men than of women indicated that their academic performance was better than that of other men or women students. Nevertheless, first-semester grades reported by men and women students did not differ by sex (Ott 1978a).

Degree Fields

Both the National Center for Education Statistics (NCES) and the Engineering Manpower Commission (EMC) report data on engineering degrees by field of engineering. NCES data are available for men and women separately, whereas EMC data by field by sex are only available for recent years. Below we analyze the degrees reported by NCES, omitting degrees in engineering technology in order to maintain comparability with degrees and enrollments reported by the Engineering Manpower Commission.

Table 10 shows the total numbers of degrees awarded to men and women annually since 1970-71, and the proportions of degrees earned by sex in each of seven major engineering fields and all other fields combined. A greater proportion of women's degrees than of men's were in chemical engineering; a greater proportion of men's degrees than of women's were in electrical and in mechanical engineering. The situation in chemical engineering and in mechanical engineering has been fairly consistent. About twice as large a percentage of women engineering students as of the men majored in chemical engineering each year. About 19 percent of the men and 11 percent of the women majored in mechanical engineering. In electrical engineering, there has been a decrease in the proportion of women. In 1970-71, 21 percent of women engineers majored in electrical, electronics, or communications engineering, but only 12.5 percent did in 1977-78. The proportion of men majoring in electrical engineering remained at about 25 percent throughout that period.

Placements and Salaries of Recent Graduates

The placement status of engineering bachelor-degree recipients is reported each year by the EMC. Among 1978 graduates, information was obtained from 934 women and 16,600 men (EMC 1978b). Among these, 12 percent of the women and 13 percent of the total class planned to attend graduate school full-time. Rates of graduate-school attendance were very similar for men and women. A larger proportion of women than of the total group (79 percent vs. 72 percent) had accepted a job offer. Conversely 1 percent of the women and 5 percent

Table 10

Proportions of Men's and Women's Bachelor's Degrees in Seven Fields of Engineering

Field	1970-71		1971-72		1972-73		1973-74		1974-75		1975-76		1976-77		1977-78	
	% of Men's	% of Women's	% of Men's	% of Women's	% of Men's	% of Women's	% of Men's	% of Women's	% of Men's	% of Women's	% of Men's	% of Women's	% of Men's	% of Women's	% of Men's	% of Women's
Engineering, General	6.3	9.7	6.4	9.1	5.6	7.0	7.1	11.0	7.2	12.4	8.1	11.1	8.0	9.7	6.9	8.5
Aerospace, Aeronautical, Astronautical	5.4	4.7	4.8	4.1	3.7	3.4	2.8	2.6	3.0	2.8	2.6	2.2	2.7	1.4	2.6	1.8
Chemical	7.9	17.5	7.9	15.4	7.7	17.1	7.8	16.8	7.7	16.7	7.8	21.0	8.0	21.0	8.9	20.6
Civil, Construction & Transportation	14.6	15.0	15.1	13.6	16.1	14.8	18.8	18.5	19.6	17.8	20.8	19.1	20.2	21.2	19.6	19.8
Electrical, Electronics & Communications	27.2	21.1	26.8	16.7	26.5	20.7	26.6	16.8	26.0	15.4	25.8	14.7	24.8	13.1	24.6	12.5
Mechanical	19.8	11.4	18.9	10.0	18.5	11.6	18.0	9.0	17.6	9.7	17.9	11.2	19.2	11.5	19.3	13.4
Industrial & Management	7.1	5.5	8.1	8.1	7.5	5.9	6.8	6.3	6.5	7.0	5.8	6.6	5.4	7.3	5.5	9.3
All Other Fields	11.6	15.2	12.0	23.2	14.5	19.5	12.1	19.0	12.5	18.2	11.2	14.2	11.7	14.8	12.5	14.1
Total N (excluding Engineering Technologies)	44,848	361	45,201	492	46,183	527[a]	42,540	697	38,961	845	37,457	1,317	39,285	2,044	43,743	3,479

Source: National Center for Education Statistics [annual editions] 1975-1978.

a. Corrected total.

of the total group were seeking work and had no offers. Thus women engineering graduates had somewhat more success in obtaining employment in 1978 than did men.

Salaries offered to bachelor-degree recipients in engineering have been determined by the College Placement Council and by Ellicott and reported by Babco (1979 and earlier editions). Salary offers for men and women were essentially equal in 1970-71 and 1971-72. Beginning in 1972-73, salary offers made to women averaged 1 to 3 percent larger than those offered to men, with the greatest difference occurring in 1976-77 (table 11). The difference in offers has declined since reaching the peak in 1976-77. There are few if any other areas of employment in which women bachelor-degree recipients receive higher offers than men do.

Reentry of Women into Engineering Programs and Positions

Because engineering is a profession that requires constant updating in order to stay current with the field, persons who are absent from the profession for a significant length of time may require retraining. One measure of the proportion of women professionals who take breaks from work was obtained in a study of women members of professional societies in a range of scientific and engineering areas (Connolly and Burks 1977). About 23 percent of the 1,125 respondents were engineers. Connolly and Burks found that only 36 percent of their respondents had ever taken a break from work of six months or longer. Of these women, 77 percent had returned to professional work and 9 percent were seeking work. The major causes of career breaks were

Table 11

Mean Monthly Salary Offers to Men and Women Bachelor's Degree Recipients in Engineering

Year	Mean Offers To Men	 To Women	Ratio of Women's to Men's Offers
1970-71	$ 885	$ 884	.999
1971-72	892	893	1.001
1972-73	905	914	1.010
1973-74	995	1002	1.007
1974-75	1109	1144	1.032
1975-76	1190	1228	1.032
1976-77	1279	1328	1.038
1977-78	1395	1431	1.026
1978-79	1529	1563	1.022

Source: Babco [annual editions] 1971-1979.

family-related, including pregnancy and the desire to devote more time to family. The median length of family-related breaks was 3.5 years. Breaks taken for other reasons were typically one to two years in duration.

Reentry programs for women scientists and engineers have recently been sponsored by the National Science Foundation (NSF). These have retrained women or updated the preparation of women scientists and engineers who have been unemployed or underemployed. Many of these women enter specially designed graduate level programs lasting one to two years. Although there is a great deal of interest in these programs from women and from NSF, few colleges and universities are expected to initiate such programs in a time of retrenchment (Roark 1980).

6. THE CASE STUDIES

Introduction

Six institutions--Vanderbilt University, the University of Washington, Purdue University, Colorado School of Mines, Prairie View A & M University, and New Mexico State University--agreed to serve as case-study institutions for this research endeavor. They were chosen because (1) their enrollments of women in engineering programs either approximated or exceeded the national average, (2) they are a heterogeneous group, representing different kinds of institutions and different parts of the country and attracting different kinds of students, and (3) they were prepared to share such data on their women students as they had and to talk freely about their efforts to attract and keep women students.

Members of the study team conducted personal interviews at the University of Washington, Colorado School of Mines, and Prairie View A & M and gathered additional information from these institutions by telephone. The other case studies are based on extensive telephone interviews with various administrators and data supplied by these institutions.

Our original case-study format anticipated that we would elicit a comprehensive set of comparable data from each institution, allowing us to compare men and women students with regard to high-school preparation and academic achievement, college performance, financial aid and other support received, attrition, engineering-field preference, pursuit of graduate education, and experience in the world of professional work. But much of this information proved not to be available, and there was much variation in the amount and kinds of data that the different institutions found it feasible to assemble for us. Therefore, to produce strictly comparable case studies would have meant discarding much information. Instead, we have sought to preserve a general comparability in structure while allowing disproportionate treatments of the component parts so that all potentially useful information could be included.

The case-study institutions are not represented here as best examples, but their experience and efforts on behalf of women students in engineering may well prove instructive for many institutions. The reader will note several common features in their experience, and in our subsequent analysis of the case studies, we consider what significance that commonality may have for women seeking engineering education and institutions seeking to provide it for them in the coming decade. But from the outset, the reader should keep firmly in mind that these case studies are shaped largely from subjective impressions offered by people with sometimes widely different perspectives. This soft data, as it is called, perhaps contains more truth than the quantitative data we assembled, but that truth is more elusive and more variously perceived.

VANDERBILT UNIVERSITY

The School of Engineering

Located in Nashville, Tennessee, Vanderbilt University was established in 1872 as The Central University of the Methodist Episcopal Church, South. A year later, it was renamed Vanderbilt University after one of its early benefactors, Commodore Cornelius Vanderbilt. A number of departments were soon organized, and the School of Engineering was begun as one of ten units within the Department of Philosophy, Science, and Literature in 1874.

Early in its history, Vanderbilt was exclusively a men's college; later, however, women were admitted under a quota system. In 1888 Vanderbilt publicly pronounced itself a coeducational institution, and in 1911 the School of Engineering officially enrolled its first woman engineering student. It was not until 1945 that the School granted its first B.E. degree to a women, but others followed in increasing numbers. Today about one-third of the School's students are women, as are two of its full-time faculty and two part-time (adjunct) faculty.

Enrollment Patterns

Although extremely variable during the 1940s, total enrollment in Vanderbilt's School of Engineering increased moderately during the 1950s and 1960s, in conformity with increases in enrollment throughout the University. At the same time, however, enrollment of women in the School rose dramatically from under 10 per year during the 1940s and 1950s to almost 100 per year at the beginning of the 1970s. Even during the 1970s, while total School enrollment fell from a high of 837 in 1970 to a low of 717 in 1974, the number of women maintained a steady figure of around 100 per year (table 12). During the last five years of the decade, enrollment of both men and women in the School was increased measurably. More significantly, the percentage of women students in the School has shown little variation from an average yearly increase of 1.4 percent during the past 15 years, despite minor setbacks in 1971 and 1978. Consequently, the percentage of women students has doubled during the 1970s and now approaches almost one-fourth of the School's students.

The fall 1980 applicant pool for the School of Engineering is about 1,050 students, including 305 (29 percent) women. Between 310 and 320 additional students will be selected for admission. It is likely that the total number of undergraduate women in engineering at Vanderbilt will remain constant or increase only slightly for the fall 1980 enrollment.

Early in the 1970s, a few students were admitted to the School of Engineering knowing that their intention was to transfer to the College of Arts and Sciences, which was their first preference. A net low of about 15 students annually occurred through these internal transfers. However, the situation reversed itself in the middle 1970s, and now the School of Engineering has a net gain of about 60 students through internal transfers.

It was observed by those interviewed that most of the early

Table 12

Vanderbilt University School of Engineering
Annual Undergraduate Enrollments 1965-1979

Year	Number Men	Number Women	Annual Increment in # of Women	Total Undergrads	% Women	Annual Increment in % Women
1965	760	27		787	3.4	
1966	773	37	+ 10	810	4.5	+ 1.1
1967	757	44	+ 7	801	5.5	+ 1.0
1968	749	48	+ 4	797	6.0	+ 0.5
1969	770	94	+ 46	864	10.9	+ 4.9
1970	727	110	+ 16	837	13.1	+ 2.2
1971	681	98	- 12	779	12.6	- 0.5
1972	645	96	- 2	741	12.9	+ 0.3
1973	630	99	+ 3	729	13.6	+ 0.7
1974	607	110	+ 11	717	15.3	+ 1.7
1975	689	168	+ 58	857	19.6	+ 4.3
1976	756	220	+ 52	976	22.5	+ 2.9
1977	784	261	+ 41	1,045	25.0	+ 2.5
1978	827	260	- 1	1,087	23.0	- 2.0
1979	856	260	0	1,116	23.3	+ 0.3

Source: Office of the Dean, School of Engineering, Vanderbilt University, 1980.

women students in engineering at Vanderbilt ended up in "soft" engineering programs (such as environmental engineering); now the tendency is for women to enroll in engineering programs across all fields in the School of Engineering.

Currently, the abilities of entering women and men students in engineering at Vanderbilt are about equal, as measured by the Scholastic Aptitude Test (SAT) and the American College Test (ACT). Combined average scores are about 1,220 on the SAT (667 on the quantitative) and about 28 on the ACT.

Women students have just started enrolling in graduate engineering programs at Vanderbilt. For example, the electrical engineering program has enrolled its first woman graduate student and two more are expected to enter in fall 1980.

About 5 percent of the women graduating from Vanderbilt with a bachelor's degree in engineering go on to graduate study or return to graduate programs (such as M.B.A. programs) after spending some time in the profession.

Factors Influencing the Enrollment of Women

No one main factor or cluster of factors stands out to explain the pattern of women's enrollments in engineering at Vanderbilt University. For convenience, therefore, factors identified in the interviews will be defined as external (those located outside the University) and internal (those attributed to the University).

External Factors

Five main external factors contributing to enrollments of women in engineering were cited in the interviews: industry and the general economy, the attitude of women students, family, institutional image, and the activities of other universities and colleges.

Industry and the general economy. The perception of those interviewed at Vanderbilt University is that enrollments in engineering for both women and men are closely tied to the availability of employment, which rises and falls with the economy. One interviewee, for instance, mentioned that the demise of the space program had a negative effect on enrollment in engineering at Vanderbilt. In addition to the economy at large, enrollments of women in engineering are perceived to be related to the active recruitment of women by industry, and this appears to be related, at least in part, to affirmative action pressures on employers.

Attitude of women students. A second obvious factor influencing enrollments of women is the attitude of women toward jobs or careers in engineering. Antitechnology sentiments and the early propensity of women to enroll in the "softer" aspects of engineering were two attitudinal factors mentioned. More generally, interviewees observed that women enrolling at Vanderbilt believe that they are equally capable of professional achievement in engineering as men--and that the profession is open to them.

Family. Many students enroll at Vanderbilt because someone in the immediate family is an alumnus. It was observed that, for some women entering the engineering program, a parent may have provided an important role model.

Institutional image. Vanderbilt is a well-known and respected university in the Southeast. It offers a "small-college environment" that includes both the liberal arts and professions. It is believed that the attractiveness of engineering programs for women at Vanderbilt is enhanced by its broad-based educational opportunities and environment. Women can study engineering at Vanderbilt while also furthering their liberal education; at the same time, they are socially accepted by Vanderbilt's relatively homogeneous (high SES) student body. One faculty member commented: "Socially, it has been easy for women entering engineering at Vanderbilt because of comparable educational and family backgrounds with the men." Another observed that women do not feel isolated in the engineering program.

Activities of other colleges and universities. It was reported that some women students who selected engineering at Vanderbilt became interested in engineering from attending "career days" hosted by other universities and colleges. Some of these career days have been sponsored by industries.

Internal Factors

Three internal factors were mentioned as contributing to the enrollment of women in engineering at Vanderbilt: recruitment, honors scholarships, and the Women in Engineering (WIE) Program.

Recruitment. If a single triggering event can be identified in the enrollment of women in engineering at Vanderbilt, it would appear to be the origin of its recruitment program. Beginning in 1967-68, a former dean of the School of Engineering and the registrar were concerned about ways of addressing declining enrollments in engineering. One response was to invite students not accepted in the College of Arts and Sciences quota to enroll in engineering. Targeted invitations were sent to all students with quantitative backgrounds who wanted to enter a science field. A second response was the development of a speakers' bureau. Engineering faculty and professional engineers representing Vanderbilt met with groups as far away as Huntsville, Alabama (about 80 miles), to discuss topics relevant to engineering education. A third response was the initiation of an active high-school recruitment program that focused on women and involved high schools throughout the Southeast and Southwest (especially Texas). The high-school recruitment program has been expanded and continued.

Results from these recruitment efforts can be seen in the dramatic increase in women's enrollments between 1968 and 1969. However, another upsurge (following a leveling-off from 1970 to 1974) occurred from 1975 to 1977. Since the recruitment effort appeared relatively stable during all these years, however, it does not seem to explain the later increases. Some interviewees attributed the initial enrollment activity to accident; then, once women began to enroll, more became interested. Yet, this momentum theory does not account for the leveling-off of women's enrollment during the past three years. University enrollment quotas and the distribution of men and women applications would need to be considered in a fuller explanation.

Honors scholarships. About 10 full academic scholarships are offered each year to the most outstanding entering freshmen in engineering. These scholarships, which extend for four years, have a total value of about $20,000 each. Those interviewed believe that the Honors Scholarship Program has increased the number of highly qualified women applicants to Vanderbilt's engineering program and has resulted in increased enrollments among women.

WIE Program. It is not clear to what extent special programs and activities for women enrolled in engineering contribute to enrollment or retention. Three programs, coordinated within the Office of the Director of Women in Engineering are: The Vanderbilt Chapter of the Society of Women Engineers (SWE), workshops for faculty and administrators on meeting the needs of women in engineering, and a special-studies course. The SWE chapter at Vanderbilt was started in 1977 and now has approximately 50 members among the 260 women in undergraduate engineering. Two needs-assessment workshops have been offered, one at Vanderbilt and one at the regional meeting of the American Society for Engineering Education (ASEE). The special-studies course, "Men and Women on the Job: Sex Roles in the Engineering Profession," was offered during 1979-80 for one credit hour and enrolled 28 students, half of whom were women.

Given the combined and varied perceptions of those interviewed, it is difficult to assess the relative importance of each external and internal factor identified above. Enrollments of women in engineering at Vanderbilt University are probably influenced to some extent by each factor.

Prospects

The Admissions Office expects that enrollments of men and women will level off over the next 5 to 10 years to about 1,050--between 1,110 during fall semester and 1,000 during spring semester (because of mid-year graduates). Women's enrollment in engineering has already leveled-off for the past 3 years to about 23 percent of the total undergraduate engineering enrollment figure. Estimates of the projected percentage of women in engineering at Vanderbilt University were consistent among those interviewed: each believed that the percentage of women in engineering programs would increase slightly to about 30 percent of total enrollments. One person commented that higher tuition rates beginning fall 1980 would limit the maximum applicant pool. Vanderbilt faculty and administrators agreed that the targeted recruitment of women would continue and could be intensified if a recession set in. Other than recruitment and the WIE program, there are no separate special programs for women and no additional ones are expected.

It was also observed that industry has not yet caught up in employment rates with the percentage of women enrolled in engineering programs. Pressure for industry to hire women engineers appears to be slackening, according to some observers, and more attention is shifting to minority students in engineering programs. "It is highly unlikely," one person commented, "that women will take over the engineering profession or assume a large number of leadership roles in the next 5 to 10 years."

Generalizability of Findings

The transferability of findings from Vanderbilt's experience to other colleges and universities is affected by several considerations. First, Vanderbilt is a private institution with relatively small, selective enrollments. It attracts students with strong backgrounds and high socioeconomic status. From the viewpoint of faculty and administrators in the School of Engineering at Vanderbilt, graduates are attractive to employers because they are academically above average, have high personal qualifications, and are well-rounded in their knowledge and skills. The majority of students at Vanderbilt are enrolled in pre-professional programs.

Finally, programs for women and minority students in engineering are administered separately at Vanderbilt. The premise seems to be that programs for women in general would not work for minorities because the social backgrounds and skills of each target population differ. The program for minorities in engineering includes a skills-development component and a dual-degree program with Fisk University.

UNIVERSITY OF WASHINGTON

The College of Engineering

The University of Washington College of Engineering, located in Seattle, awarded its first degree in mining engineering in 1900. In subsequent years, reflecting technological needs of the growing Pacific Northwest, it added degrees in civil engineering (1901), electrical engineering (1902), mechanical engineering (1906), chemical engineering (1907), aeronautical engineering (1929), and nuclear engineering (1955). With a few changes and additions this list reflects the current departments of the College: aeronautical engineering has become aeronautics and astronautics; mining has become ceramic and metallurgical engineering, mechanical has become mechanical and industrial engineering, and a department of computer science has been added. Additional engineering specialities available to students reflect cooperation between existing departments in the College and other strong programs within the University such as health sciences, fisheries, and urban planning. They include ocean engineering, bioengineering, transportation and urban systems planning, and social management of technology.

Women constituted 16.4 percent of the undergraduate enrollment of the College in autumn of 1979. Proportionately fewer women were represented on the faculty (5 of a faculty of about 175). Four of these women, however, were tenured. Currently there are no women within the academic administration of the College. However, much of the impetus for enrolling women students and recruiting women faculty occurred during the tenure of a woman who was Associate Dean of the College between 1973 and 1976.

Enrollment Patterns

Enrollments in the College of Engineering appear to be somewhat more subject to fluctuation than those of the University as a whole. Figure 1 illustrates the fall-quarter enrollment patterns from 1969 through 1979. At its most recent enrollment ebb in 1973, the College enrolled a total of 1,670 undergraduates--of which 56 or 3.4 percent were women. At its current apogee, the College enrolled 3,660 undergraduates, including 599 or 16.4 percent women. Given a cap on overall University enrollments, the College is expected to reduce its undergraduate student body to 2,700 in the coming years. The graph indicates that while total enrollments have fallen and risen, the enrollment of women has increased rapidly from a steady state of below 42 through 1973 to nearly 600 by the 1979-80 academic year.

While the annual increase in the number of women has been steady, fluctuations in overall enrollments have created some variation in annual increases in the percentage of women. As shown in table 13 percentage increases due to decreasing overall enrollments began in 1971, two years before the absolute number of women began its steady climb.

In the enrollment of women by program, some clear variations occur across programs and within programs over time. Those most favored by women in 1979-80 (table 14) are computer science (27.9 percent), chemical engineering (25.1 percent), industrial engineering

Figure 1

Undergraduate Enrollments U. W. College of Engineering

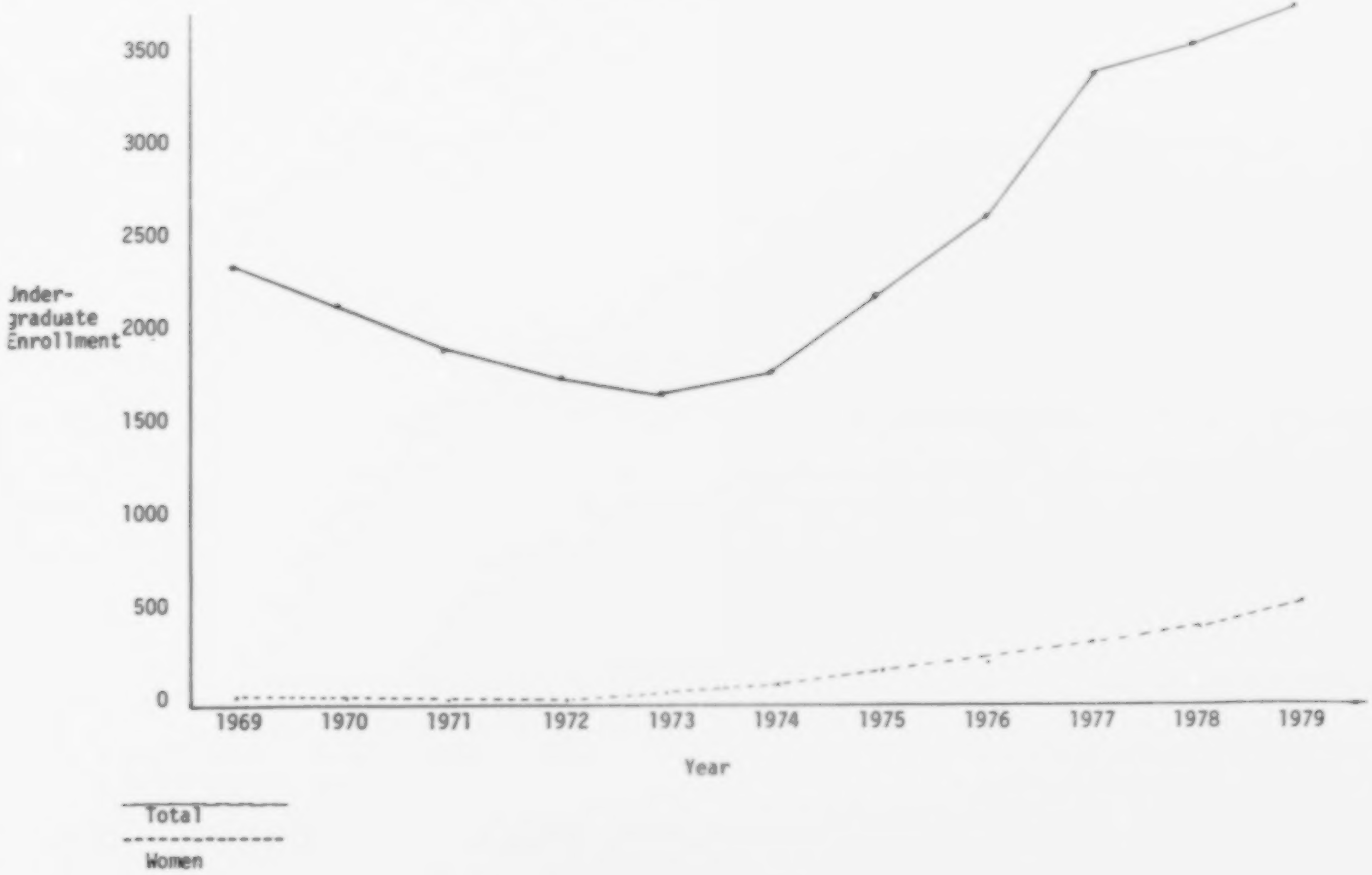


Table 13

University of Washington College of Engineering

Annual Undergraduate Enrollments 1969-1979

Year	Number Men	Number Women	Annual Increment in # of Women	Total Undergrads	% Women	Annual Increment in % Women
1969	2,311	41		2,352	1.7	
1970	2,080	37	-4	2,117	1.7	0
1971	1,878	35	-2	1,913	1.8	0.1
1972	1,697	34	-1	1,731	2.0	0.2
1973	1,614	56	+22	1,670	3.4	1.4
1974	1,711	102	+46	1,813	5.6	2.2
1975	2,072	195	+93	2,267	8.6	3.0
1976	2,443	292	+97	2,735	10.7	2.1
1977	3,002	397	+105	3,397	11.7	1.0
1978	3,034	467	+70	3,501	13.3	1.6
1979	3,061	599	+132	3,660	16.4	3.1

Source: Registrar's Office, University of Washington, Fall Statistics.

Table 14

ANNUAL REPRESENTATION BY WOMEN WITHIN UNDERGRADUATE ENGINEERING PROGRAMS AT THE UNIVERSITY OF WASHINGTON

	AERONAUTICS & ASTRONAUTICS		CERAMICS		CHEMICAL ENGINEERING		CIVIL ENGINEERING		COMPUTER SCIENCE		ELECTRICAL ENGINEERING		GENERAL		INDUSTRIAL		INTER-DISCIPLINARY		MECHANICAL		METALLURGY		MINING	
Year	Enroll-ment	% Women	Enroll-ment	% Women	Enroll-ment	% Women	Enroll-ment	% Women	Enroll-ment	% Women	Enroll-ment	% Women	Enroll-ment	% Women	Enroll-ment	% Women	Enroll-ment	% Women	Enroll-ment	% Women	Enroll-ment	% Women	Enroll-ment	% Women
1969	263	1.6	61	4.9	155	1.9	286	.3	-	-	577	1.7	511	2.7	24	4.1	-	-	433	0.7	25	4.0	17	5.9
1970	195	2.1	63	7.9	144	2.8	266	.7	-	-	551	1.6	386	2.6	58	0.0	-	-	399	0.5	35	0.0	20	5.0
1971	133	1.5	45	6.7	109	2.8	265	1.8	-	-	527	2.1	376	2.1	53	1.8	-	-	366	0.5	27	0.0	12	0.0
1972	77	2.6	23	13.0	78	2.6	248	3.6	-	-	424	1.2	508	1.9	37	2.7	5	0.0	298	0.7	26	0.0	7	0.0
1973	55	1.8	14	21.4	78	5.1	236	2.5	-	-	414	.7	618	5.8	18	0.0	7	0.0	206	1.0	20	5.0	4	0.0
1974	50	4.0	19	10.5	90	10.0	235	4.3	-	-	421	1.9	750	8.0	13	0.0	17	23.5	190	2.6	23	8.7	5	0.0
1975	75	6.7	26	11.6	119	13.4	233	9.4	5	0	507	3.2	981	11.7	13	0.0	12	33.0	271	4.8	23	4.3	2	0.0
1976	97	6.2	27	22.2	158	17.7	320	9.7	27	18.5	557	4.1	1,171	14.3	19	5.3	13	30.7	317	4.4	28	17.9	1	0.0
1977	98	2.1	28	21.4	191	22.5	409	11.7	60	25.0	589	4.9	1,576	13.7	63	17.5	15	6.6	337	6.5	32	12.5	1	0.0
1978	115	7.0	37	18.9	193	22.8	355	16.1	89	31.5	535	6.9	1,636	13.9	95	21.1	14	21.4	397	7.8	35	11.4	0	0.0
1979	126	7.9	32	18.7	171	25.1	276	21.4	86	27.9	457	8.3	1,981	17.6	82	22.0	24	20.8	390	11.3	34	8.8	1	0.0

Source: University of Washington, Registrar's Office, Autumn Quarter Statistics, Annual 1969-79.

(22.0 percent), civil engineering (21.4 percent), and interdisciplinary programs (20.8 percent). Least favored were mining (0 percent), aeronautics and astronautics (7.9 percent), electrical engineering (8.3 percent), metallurgy (8.8 percent), and mechanical engineering (11.3 percent). Ceramics and general engineering, with 18.7 percent and 17.6 percent, respectively, fell close to the national average for women in engineering. Comparison of national data by program for 1978 with comparable data from the University of Washington (table 15) suggests two or three inconsistencies. Enrollment of women in computer science, for instance, was nearly double at the University of Washington than the national figure (31.5 percent versus 16.8 percent). This might be explained, at least partially, by the fact that the computer science program was formally established at the University in 1975, at a period when the College was actively recruiting women. Since the program was new, it offered employment opportunities in a field that was not yet sex-stereotyped.

Likewise, enrollment in the University's program in civil engineering appeared higher in 1978 than national figures, with 16.1 percent women against a national figure of 10.4 percent. The growth patterns (and their antecedents in the national and regional labor markets) are related to this difference. Nationally, enrollments in civil engineering increased from 42,981 to 44,162 students between 1977 and 1978. Of this increase, more than half were men. At the University of Washington, however, enrollments in civil engineering decreased from 409 to 355 between 1978 and 1979. While the decrease numbered 54

Table 15

Percentage of Women Enrolled in Selected Undergraduate Engineering Curricula at The University of Washington with National Comparison

Field	Fall '77 % Women U. W.	Fall '77 % Women Nationally	Fall '78 % Women U. W.	Fall '78 % Women Nationally	Fall '79 % Women U. W.	Fall '79 Size of Program U. W.
Chemical	22.5	18.3	22.8	19.4	25.1	171
Industrial	17.5	16.0	21.1	19.1	22.0	82
Computer	25.0	15.8	31.5	16.8	27.9	86
General	13.7	12.1	13.9	13.8	17.6	1,981
Civil	11.7	9.5	16.1	10.4	21.4	276
Mechanical	6.5	6.2	7.8	7.2	11.3	390
Electrical	4.9	5.5	6.9	6.5	8.3	457
Ceramics	21.4	NA	18.9		18.7	32

Source: National Data: Engineering Manpower Commission of Engineers Joint Council 1977, 1978.
University of Washington Data: U. W. Office of the Registrar, Autumn Statistics, Annual.

students, the drop in the number of men was 63 while women increased by 9 between the two years. One faculty member attributed the women's interest in civil engineering to the ease it provides for reentry of people with backgrounds in biology--particularly in atmospheric and marine specializations. Another attributed the interest to the recent application of civil engineering to environmental issues.

Finally, the program in ceramics, which included 18.7 percent women in its undergraduate enrollments in 1978, had no national data or may have been sufficiently small to be considered unimportant. It is a small program at the University (37 students in 1978) but consistently maintains an enrollment of women around 20 percent.

With the exception of civil and chemical engineering, the programs enrolling the highest proportions of women tended to be quite small and consequently areas where the addition of relatively low numbers of women could quickly increase the proportion of women. In large areas such as general engineering (1,981 students in 1979), electrical engineering (457 students), and mechanical engineering (390 students), the rate of increase in the proportions of women has been slower than in smaller areas, with the exception of aeronautics and astronautics.

Selectivity in admissions has varied with total enrollments in the College of Engineering. When enrollments were low, in the mid-1970s, admission to the University was adequate for admission to the College. By 1979-80, however, in response to a cap on its admissions, the College began to require new students to enter the University through the College of Arts and Sciences and transfer into the College of Engineering after a year of course work. At the same time, it proposed an exemption to this policy for new women and minority students. The College of Engineering and University administration are currently considering how to implement these new admissions policies in such a way that they have neither an adverse impact on women and minorities nor violate equal opportunity laws.

When women were being accepted in low numbers--and as their numbers increased through the mid-1970s--faculty, administrators, and students alike reported that they tended to be strong students. Indeed, academically weak women tended not to apply. Observations on women who have been students over the past few years suggest that they have become comparable, on the average, with male students. This may reflect either an increased selectivity of male students or simply more applications for entrance be greater numbers of women as engineering becomes a more acceptable field of study for them.

We are limited in observations on retention. While table 16 shows enrollment of women by class over a 10-year period, the effect of transfers on numbers in post-freshman years remains unknown. Beginning with the entering class of 1971, every subsequent class shows more absolute numbers of women in the senior year than the freshman year, an indication that students are transferring into the College. The percentage of women in the freshman and senior

Table 16

Numbers and Percentages of Women Enrolled in the University of Washington College of Engineering by Class

Entering year	Number & % of women as freshmen		Number & % of women as sophomores		Number & % of women as juniors		Number & % of women as seniors	
1966							9	1.4
1967					11	2.0	10	1.5
1968			6	1.2	9	1.9	8	1.4
1969	14	2.5	8	1.8	10	2.0	10	1.8
1970	10	2.4	11	2.5	10	2.2	9	1.8
1971	4	1.3	3	0.8	9	2.0	12	2.5
1972	9	3.1	12	3.7	22	4.7	29	5.5
1973	22	6.8	31	8.1	32	5.7	38	6.0
1974	23	6.3	37	8.0	54	7.7	55	7.6
1975	71	13.3	72	12.0	90	10.7	95	10.7
1976	97	15.7	113	14.7	140	14.5	151	14.8
1977	105	12.8	106	15.7	136	16.0		
1978	94	12.3	99	14.8				
1979	156	17.7						

years shows a variation that is sometimes high and sometimes low, but with no apparent pattern over time. The impression of faculty within the College is that retention of women students is at least as good if not better than retention of men. Concern for a moral obligation to do everything possible to retain both women and minority students has recently led to outside funding to hire a special adviser for these groups.

Faculty, placement office staff, and women students report that employment opportunities are high for women engineers in both number of options and salary levels. The demand is attributed not only to affirmative action pressure on federal contractors (Boeing Company is the largest employer in the Puget Sound area) but also to the competence of women already in the field and women students in their academic work. The demand for women in the job market was cited by several people as a factor limiting enrollments of women at the graduate level. Generally, it was assumed that women engineers entering the labor force directly from undergraduate programs would enter managerial ranks within three to five years.

The success of women in the cooperative education program, where students alternate between six months in the field and six months in classes, has further enhanced their attractiveness to employers. Women have tended to participate in the program at a rate somewhat greater than their representation within the College, constituting about 23 percent of the approximately 170 participants in the program.

Factors Influencing the Enrollment of Women

Internal and external factors affecting the enrollment of women in the College of Engineering are not only highly interrelated but also complicated by the varying perceptions key actors have of them--and the ways they react to them. For the sake of clarity, however, we will consider these factors in terms of (1) program development within the College to increase the enrollment of women, and (2) the effects of unintended internal and external forces on both program development and actual enrollments.

External Factors

In the state of Washington, Boeing Company is the major employer of engineers. With its corporate headquarters in Seattle, there are firm, if informal, ties between Boeing and the College of Engineering. Boeing was the first major contributor to the earliest program for women in engineering, the Women's Career Conference in 1973, which was used as a model by other engineering schools, such as the University of California at Berkeley. According to a former Dean, his Associate Dean approached the company, which was quite open to funding programs ultimately to turn greater numbers of women and minority engineers out into the field. Others noted that Boeing and other industries actively communicated their need for greater numbers of women and minority engineers to colleagues within the College of Engineering. By 1978-79, over twenty different companies were cited for their generous contributions to the School Relations Program (see table 17). In effect, the School Relations Program offered a

Table 17

Sponsoring Organizations

School Relations Program

College of Engineering, University of Washington

ALCOA Foundation
AMOCO Foundation, Inc.
Atlantic Richfield Company
ASARCO Incorporated
Battelle Northwest
Bechtel Power Corporation
Boise Cascade Corporation
Boeing Company
Engineering Council for Professional Development
Hewlett Packard
IBM Corporation
Institute of Electrical and Electronics Engineers, Seattle Section
Kaiser Aluminum & Chemical Corporation
Longview Fibre Company
National Fund for Minority Engineering Students
Pacific Northwest Bell
Rockcor
Rockwell/Hanford Operations
Scott Paper Company
Shell Companies Foundation
Standard Oil Company of California
Union Oil Company of California
University of Washington
URS Company
Weyerhaeuser Company

Source: University of Washington, Annual Report, 1979.

solution to both College of Engineering enrollment concerns and to industrial affirmative action hiring problems. The location of the University of Washington in an industrial center of the state enhanced the likelihood of support from nearby industries.

Professional organizations, too, added to the environmental fabric facilitating the enrollment of women in the College of Engineering. Whether in response to the times, to industrial needs for greater numbers of women and minorities, or to concerns of individuals within their organizations, local and national professional societies contributed both money and energy to the University's efforts to increase the enrollment of women and minorities. The Eastern Washington Chapter of the Society of Women Engineers (SWE) coordinated one of the career conferences, and the University's SWE contributed speakers and other resources to a number of the School Relations Program projects. Other contributing professional groups included: the Engineering Council for Professional Development, the Institute of Electrical and Electronics Engineers, and the National Fund for Minority Engineering Students.

A final environmental effect that may have indirectly influenced the enrollment of women dates back to the student disruption of the sixties. In response to student concerns about the rigidity of the engineering curriculum, it was reviewed in 1970 to permit greater flexibility and to enable students to transfer into the College of Engineering from the community colleges or other programs within the University. The effect may well have allowed reentry women to give more serious thought to engineering as a career.

Internal Factors

College of Engineering special programs, with operating budgets totalling over $100,000, are funded primarily from outside sources committed to increasing the number and enhancing the quality of minorities and women who have chosen engineering or science as a career. Eight formal programs associated with the School Relations Program of the College are listed in table 18. These range from career conferences to scholarship programs. The School Relations Program is directed by an engineering faculty member and is supported by secretarial help and a half-time liaison between the schools and the College. This liaison position is funded by outside money channeled through the Seattle schools, while the faculty director is supported by the University through partial released time from teaching responsibilities. Additional staff for specific projects are hired as called for from project funds. In addition, the program assistant for the College's Advisement Center also serves in coordinating programs, and faculty and students within the school contribute time to the various programs.

The evolution of the School Relations Program is an important component in an understanding of the forces affecting the enrollment of women. The program originated in the early seventies as a response to rapidly decreasing enrollments within the College and an effort to improve the image of engineering as a field; this would, in turn, attract more students. It was begun under a new Dean, who had appointed a senior woman faculty member as Associate Dean for

Table 18

University of Washington College of Engineering
School Relations Program 1978-79

Junior High Visitation Program: Motivational math and science activities presented to 5,500 students in 7th, 8th, and 9th grades in seven minority-impacted schools in Seattle.

Career Conferences in Engineering: Three conferences initiated by U. W. held in cooperation with professional organizations and other universities held in three Pacific Northwest locations. Attended by 385 women and 85 minority high school and community college students. Fifth year for conferences.

MITE Program: (Minorities Introduction to Engineering) 40 high school juniors, two week on-campus program. Heavily subscribed by women.

Mini-MITE: A special two day version of MITE to address the many applicants for whom where wasn't space in the MITE program. Attended by 165 high school juniors, many of whom were women.

PREFACE: Proposed and received Department of Energy funding for high school visitation program aimed at both women and minorities in the 9th and 10th grades in six Seattle high schools.

Yakima Valley Project: Planned, organized, and funded for 1979-80 year, school visitation program in minority-impacted Yakima Valley section of Washington.

Scholarship program for minorities and women: (Distributed to about 44 students in 1977)

Teacher In-Service Program: "Careers for Women in Science and Technology" continuing education course designed for women considering a career change or reentry into the workforce.

Community Relations. Almost without exception, observers within the College and University at large regard this Associate Dean as central to initiating efforts to recruit both women students and faculty. She, however, suggested that both recruitment efforts and increased enrollment were simply a product of the times--involving a changed image of engineering, the growth of jobs for women engineers, and changes in the expected role of women in society.

The current director of the program, appointed on return from a sabbatical leave in 1974, brought with him a realization that women and minorities represented an untapped pool of potential applicants. He also exhibited a skill in fundraising and an ongoing commitment to increase the number of women and minorities in the College that remained even after enrollment pressures dropped.

The director defines his role primarily as a fund-raiser. Most day-to-day coordination of actual programs is the responsibility of the half-time school-college liaison staff member. Like the former Associate Dean and the Director of the School Relations Program, she has been effectively persistent and energetic in working for the concerns of the program.

Beyond this core of individuals and some College administrators, few faculty and staff see the College as making a special effort to recruit women students. These programs are "low profile," funded from outside sources. Insofar as they demanded neither resources from existing programs nor changes in ongoing programs, they were not threatening to faculty in the College. On the whole, faculty seemed unconcerned about the enrollment of women. Since there had always been a few women students, their presence was not totally new, and increased numbers of women at the time served to help meet the problem of low enrollments.

Thus, these programs seem to have continued based on the persistence and energy of a few people within a benign environment, that is, an administration which was seen as reasonably supportive and a faculty which was not obstructionist. The impact of the programs was most likely evident at the margins: they affected those students who were somewhat undecided, while the bulk of the women were perceived to be quite committed. This marginal difference, however, is probably the measure of difference between enrollment of women at the University of Washington and the lower national average. An evaluation of the effects of these programs on women enrolled in the 1978-79 year indicated that about one-third of the respondents felt they had some positive influence (though not necessarily the determining influence) on their decision to pursue an engineering career.

Prospects

A retired Dean of the College of Engineering carefully pointed out the folly of predictions. He viewed the increased enrollment of women very much as a natural outcome of environmental forces, any of which could change in unforeseen ways. A current Associate Dean, on the other hand, viewing both institutional efforts and environmental forces, expects the enrollment of women in engineering to level off at their representation in the population at large. Analysis of enrollment trends over the past ten years, however, shows no sign that the enrollment of women in the College of Engineering has begun to level off (figure 1).

Less than optimistic about the stability of the current trend, a former Associate Dean expressed concern that the commitment of industry to the hiring of women was more token than real, and that if the economy were to shift--particularly in relation to the engineering labor market--women would again have greater difficulty than men in getting and keeping jobs in the field. This perspective may well have reflected her own experience in attending college in an engineering program during World War II, when enrollments of women in engineering were relatively high. As that trend quickly shifted downward after World War II, she felt the current trend could also do the same.

Generalizability of Findings

The University of Washington is the major research university in a state with a growing population, a thriving economy, and the sixth highest number of engineers per capita of all states. The University is limited by the state legislature in the number of students it can enroll annually, and it consistently turns many away. In terms of quality, it is regarded as one of the top 20 universities in the nation, and it aspires to be higher. This combination has led it to direct the College of Engineering to cut enrollment and increase the quality of faculty research. These circumstances may be representative of only a few of the more highly reputed state universities in the country.

The generalizability of its experience to other groups or programs (such as minorities or medicine) depends very much on the degree to which internal or external factors have a greater effect on the enrollment of women. Internal strategies aimed specifically at women, for example, do not necessarily affect minorities. Other programs depending on math and science preparation in junior high school could, however, apply the methods used by the College of Engineering to its own recruiting efforts. Indeed, greater efficiency could probably be achieved by combined recruiting and preparation efforts.

PURDUE UNIVERSITY

The College of Engineering

Purdue University, whose main campus is at West Lafayette, Indiana, was founded in 1869, primarily as a technical school in engineering and agriculture. Today Purdue offers instruction through its dozen schools, which include Nursing; Pharmacy; Health Sciences; Humanities, Social Science, and Education; Management; Consumer and Family Sciences; Veterinary Medicine; Agriculture; and Engineering. Four regional campuses, in addition to the main one at West Lafayette, recently reported a combined enrollment of more than 67,000 full-time and part-time students.

Over the years, Purdue has expanded its engineering curriculum to include 12 major areas: aeronautics and astronautics, agricultural engineering, chemical engineering, civil engineering, construction engineering, electrical engineering, industrial engineering, interdisciplinary engineering, land surveying, materials engineering, mechanical engineering, and nuclear engineering. The curriculum also includes an optional five-year Cooperative Education Program, in which students alternate periods of course work with work at consulting firms, government agencies, and industries. Also available to engineering students are opportunities for overseas study and public-service research.

According to a recent Purdue Bulletin, the University has been the largest or second largest in undergraduate engineering enrollment in the United States for the past 50 years. Total undergraduate enrollment in engineering for 1979 was 6,860.

In addition to its growth in overall undergraduate enrollment, Purdue reports that the number of women undergraduates has increased dramatically. In the past five years, the number of women undergraduates has almost tripled (from 465 in 1975 to 1,143 in 1979). In 1979, about 17 percent of the engineering undergraduates at Purdue were women; nationwide that percentage was about 12. In connection with this increased interest in engineering among women, the School has formed a student chapter of the Society of Women Engineers (SWE) and has established merit awards for women engineering students.

Of the School's approximately 325 faculty members, three women teach full-time.

Enrollment Patterns

Although the College of Engineering experienced a decline in undergraduate enrollment during the early seventies, the number of women enrolled during that time was increasing steadily (see table 19). Total enrollment dropped from 5,035 in 1970 to 4,665 in 1971, to 4,262 in 1972, and to 4,275 in 1973. The number of women rose, however, from 60 in 1970 to 78 in 1971, to 87 in 1972, and to 145 in 1973. Later in that decade, both general undergraduate enrollment and number of women increased considerably. From 4,474 in 1974, total undergraduates numbered 5,000 in 1975, 5,899 in 1976, 6,255 in 1977, and 6,610 in 1978. Women undergraduates numbered 246 in 1974, 465 in 1975, 646 in 1976, 828 in 1977, and 995 in 1978.

Table 19

Purdue University College of Engineering

Annual Undergraduate Enrollments 1968-1979

Year	Number Men	Number Women	Annual Increment in # of Women	Total Undergrads	% Women	Annual Increment in % Women
1968	5,201	43		5,244	.8	
1969	4,969	47	4	5,016	.9	.1
1970	4,975	60	13	5,035	1.2	.3
1971	4,587	78	18	4,665	1.6	.4
1972	4,175	87	9	4,262	2.0	.4
1973	4,130	145	58	4,275	3.3	1.3
1974	4,228	246	101	4,474	5.4	2.1
1975	4,535	465	219	5,000	9.3	3.9
1976	5,253	646	181	5,899	10.9	1.6
1977	5,427	828	182	6,255	13.2	2.3
1978	5,615	995	167	6,610	15.0	1.8
1979	5,717	1,143	148	6,860	16.7	1.7

Source: Office of the Dean, School of Engineering, Purdue University, 1980.

By 1979, total enrollment and women's enrollment were the highest of the decade. About 1,150 women were participating in Purdue's engineering programs and accounted for almost 17 percent of the total enrollment (6,860).

According to a progress report on Women in Engineering at Purdue, the schools of chemical, civil, and mechanical engineering reported the highest enrollments of undergraduate women from 1974 to 1978. This contrasts the years 1968 to 1973, when aeronautics and astronautics attracted high percentages of women students, relative to the other curricula within Purdue's Engineering School.

In 1978, chemical engineering at Purdue had the largest enrollment of women (124), followed by electrical engineering, 92; engineering science, 91; and mechanical engineering, 84. Nationwide figures for that year also indicate chemical engineering attracted the highest percentage of undergraduate women. (See table 20). Those national figures also show that mechanical and electrical engineering had the lowest percentages of women.

No women pursued the nuclear-engineering curriculum at Purdue from 1968 to 1975. From 1976 to 1978 the numbers of female undergraduates in that field were, respectively, 5, 8, and 7.

The average SAT math scores of Purdue engineering students for the even-numbered years from 1968 to 1976 and for 1977 indicate that men had slightly higher scores than women for three of those years (1968, 1976, 1977). Women's scores were slightly higher than men's in 1970 and 1974. In 1972, the average SAT math score for men was

Table 20

Trends In Enrollment of Women Engineers: By Schools

School	Undergraduates										
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Aeronautical & Astronautical	3	9	5	8	8	9	10	13	17	26	29
Agriculture	-	-	0	0	0	2	2	3	4	4	20
Chemical	2	2	2	4	5	6	23	65	117	37	124
Civil[a]	2	3	3	4	8	11	15	41	66	82	92
Electrical	3	1	3	9	10	8	6	16	34	76	91
Engineering Sciences	1	0	0	1	1	1	1	1	Discontinued School		
Industrial	1	0	2	2	1	4	8	18	42	62	86
Interdisciplinary Engineering	-	-	5	9	10	9	13	25	31	44	61
Materials	1	1	0	0	0	1	4	6	13	16	20
Mechanical	1	4	4	4	5	9	20	36	52	68	84
Nuclear	-	-	-	-	-	-	-	-	5	8	7
Freshman & Undecided	29	26	36	38	39	85	144	241	265	298	381
TOTAL	43	46	60	78	87	145	246	465	646	828	995

[Source: Purdue University, Women in Engineering at Purdue University (1979)]
a. Includes Construction Management and Land Surveying.

57 points higher than that of the average for women. Statistics for those same years also indicate that the high-school class rank for women was steadily 8 to 11 percentile points higher than the men's.

Factors Influencing Women Enrollments

External Factors

Administrators and faculty at Purdue's School of Engineering identified conditions external to the University that have influenced women enrollments: (1) employment opportunities and salaries in engineering, (2) industry support, (3) the national women's movement, and (4) image of the Institution.

Job opportunities and salaries in engineering. Interviews with faculty and administrators at Purdue indicated that women seem to have become aware of the professional opportunities and salaries in engineering. (According to a report by a consultant at Arthur D. Little, average starting salaries for women engineers have been up to 4 percent higher than those for all starting engineers.) In addition, the demand for engineers is high.

Industry support. Those interviewed also observed that industry has actively supported and recruited women in engineering, possibly in reaction to government pressure for affirmative action. Various industries have offered scholarships for women, sponsored special activities (for example, a career day for women considering careers in engineering), and recruited women engineering graduates. In addition, industry has cooperated by identifying role models (that is, women who are engineers), and by encouraging them to participate in Purdue's recruitment and retention programs for women.

National women's movement. The women's movement has encouraged women to pursue careers that have traditionally been male-dominated. Equal-rights legislation has further endorsed this pursuit. Several interviewees noted that these facts may have contributed to changes in attitudes among women; that is, many women increasingly have realized that they could participate in the engineering profession.

Institutional image. In addition to its reputation for outstanding engineering education, the University has become recognized as a leader of women-in-engineering programs and has received considerable publicity.

Internal Factors

The interviews also suggested that efforts on the part of Purdue's Engineering School have effected changes in the enrollment rates of women.

Recruitment activities. Purdue has conducted extensive recruitment activities, including career-awareness programs for junior-high and high-school students, week-long summer conferences for high-school students, a slide-tape show ("The Feminine Angle") for use by high-school teachers and counselors, career-information booklets, high-school visits by members of the Society of Women Engineers, and conferences for high-school teachers and counselors. In addition, the College Board Student Search Service identifies prospective women students for Purdue to contact.

Administrative leadership and support. According to a progress report on Women in Engineering at Purdue, the Engineering School in 1968 recognized "the need to encourage more women to enter the field of engineering" (Purdue 1979a). That year a staff position was created in the Department of Freshman Engineering for the purpose of increasing women's enrollment. As a result, a comprehensive four-year plan to increase enrollments was developed and implemented in 1974. Support came from the Department of Freshman Engineering and grants from industry.

Additional impetus to these efforts at increasing the number of women students came from the overall enrollment decline at Purdue in 1972 and 1973: the School became increasingly interested in reaching untapped pools of prospective students, of which women constituted a large segment.

Retention activities. Because enrollment is affected by both recruitment and retention, and because the retention of women students in engineering at Purdue was extremely low in the late 1960s and early 1970s, retention activities have been considered as a major contributing factor to the increase in women students in the late seventies. In addition to its counseling services and student organizations, the Engineering School added a special seminar to provide women with social support and help them develop additional career skills. With the aid of these retention activities, the four-year attrition rate of women in engineering has been reduced from 79 percent of the freshman class of 1968 to 39 percent of the freshman class of 1972. The 39 percent attrition rate for women, equal to that for men in 1972, has remained steady for the past three years at Purdue.

Student organizations. According to administrators at Purdue's Engineering School, the most active and outstanding student organization for women is the Society of Women Engineers, which has received national recognition. About 70 percent of the women now enrolled in engineering are members. Many of these members assist the School in recruiting women students; they also develop and maintain social-support systems, advertise summer jobs in the newsletter they publish, attend professional meetings, host awards banquets, and sponsor various social activities.

Scholarships. Merit scholarships are awarded annually to women students in engineering.

Location. A final factor that may attract women engineering students is the location of the University. Located 60 miles from a large urban area, the physical setting is viewed as more attractive than that offered by large, urban universities.

IV. Future Prospects

In general, those interviewed at Purdue offered conservative estimates for future enrollments of women in engineering at their institution. At present, women constitute about 17 percent of the total undergraduate enrollments in engineering at Purdue; women are expected to represent 20 to 30 percent of the engineering enrollment at Purdue over the next 5 to 10 years. This projection is based on observations that: (1) the University's out-of-state enrollment costs will have a leveling effect on women enrollments, (2) many of the external and internal forces that have provided the impetus for women enrollments in engineering will decrease in strength, and (3) the decline in the number of high-school graduates will directly affect the applicant pool. However, these projections do not necessarily take into account that engineering will continue to be an attractive job market and career opportunity for women and that 30 to 35 percent of the high-school graduates in Indiana who are qualified for and interested in engineering or related sciences are female. If women do not increase in numbers proportionately to men, their percentages nevertheless could increase. Those who advocate the "critical mass" theory of women enrollments in engineering believe that the number of women entering engineering programs will not decrease.

Special programs for undergraduate engineering will be emphasized less in the future, according to the Purdue interviews. Emphasis is expected to shift to minorities and to women graduate students. In addition, industry's support of women in engineering at Purdue has weakened. Corporations give smaller grants to women's programs and appear to be more interested in supporting minorities and sponsoring activities that will benefit specific companies.

V. Generalizations

Purdue University is somewhat distinctive in that about half of its students today come from out-of-state. In addition, the relatively large size of women enrollments in engineering enables more resources to be devoted to special programs for women than would be possible at schools with a small number of women engineering students. Those interviewed at Purdue believe that the basic strategies used at their University to recruit women into engineering can be applied to other prospective students and curriculum areas.

COLORADO SCHOOL OF MINES

Institutional Background

Colorado School of Mines (CSM), a state-supported institution emphasizing energy and mineral engineering, is located in Golden, Colorado. Although it offers students nondegree preparation in the humanities and social sciences, it is a freestanding engineering school training production-oriented specialists in 10 major areas: chemistry, chemical and petroleum refining, geology, geophysics, mathematics, metallurgy, basic mineral engineering, mining, petroleum, and physics. CSM has an international reputation for the rigor of its program and the technical competence of its graduates. Founded in 1874 to provide trained engineers for the mining industry of Colorado, CSM now draws its student body from across the United States and from abroad.

Enrollment Patterns

Enrollment Changes

CSM has been coeducational since its founding, but women constituted a numerically insignificant segment of the student body prior to 1970. In 1970, 48 of the 1,325 undergraduates were women, and 25 of the 48 were in the freshman class. By 1979, 342 of the 2,166 undergraduates were women. Table 21 shows the growth in female undergraduate enrollment from 1970 to 1979. Female enrollment doubled (from a very modest base) from 1970-71 to 1973-74, a period of modest growth for CSM. The rising number of women accounted for 44 percent of enroll-

Table 21

COLORADO SCHOOL OF MINES

ANNUAL UNDERGRADUATE ENROLLMENTS 1970-1970

Year	Total Enrollment	Female Enrollment	Female Enrollment As % of Total
1970	1,325	48	3.6%
1971	1,311	63	4.8%
1972	1,308	77	5.9%
1973	1,432	95	6.6%
1974	1,500	112	7.5%
1975	1,693	169	10.0%
1976	1,848	205	10.0%
1977	2,004	260	13.0%
1978	2,085	297	14.2%
1979	2,166	342	15.8%

ment growth during this period. CSM experienced more rapid growth between 1974-75 and 1977-78, with undergraduate enrollments increasing by one-third. Nevertheless, women more than held their own, numerically, as their numbers more than doubled. Since 1977-78, the pace of enrollment growth has slackened somewhat, with much of the growth which has taken place traceable to a continuing influx of women. During this recent period women accounted for 51 percent of total enrollment growth. In fall 1979, women constituted 22 percent of the entering freshman class and almost 16 percent of the total undergraduate enrollment. Overall, women accounted for 35 percent of the increase in enrollment during the 1970s.

Background

For nearly a century, CSM's tradition of field and production engineering appears to have deterred all but the most determined women from seeking an engineering degree. Thus women attending CSM were regarded as highly motivated and highly qualified, perhaps more so than their average male counterparts. Table 22 supports the view that women have been at least as highly qualified as men. Both ACT scores and high-school grade point averages show women equal to or outscoring entering males. One concern is a possible decline in the level of academic preparation among women as their numbers increase. In other words, quantity may dilute quality. To the extent ACT scores and grade point averages reflect potential performance capabilities, there is little evidence to suggest the quality of entering freshmen women has declined. From 1972-73 to 1979-80 women's ACT math average

Table 22

ACT SCORES AND G.P.A. FOR STUDENTS ENTERING THE COLORADO SCHOOL OF MINES 1972-1979

	ACT English		ACT Math		G.P.A.	
Year	Men	Women	Men	Women	Men	Women
1972	21	23	29	29	3.43	3.63
1973	22	24	29	30	3.34	3.50
1974	21	24	28	29	3.41	3.75
1975	21	23	29	28	3.50	3.73
1976	22	23	29	28	3.60	3.72
1977	21	23	29	28	3.53	3.69
1978	22	24	29	28	3.55	3.76
1979	22	24	29	28	3.60	3.75

scores declined from 29 to 28, while English scores rose from 23 to 24. Their grade point averages also showed a slight increase, although not as much as the men, who started from a lower base. While the entering class may be more homogeneous than before, this may reflect improvement in the men rather than declining quality in the women. It is worth noting the data conflict with the perceptions of a slight reduction in the abilities of entering women voiced by several informants.

Program Distribution

As the number of women has increased there has been a trend toward a more even distribution among majors. Table 23 highlights the concentration of women by major in 1970: mathematics, chemistry, and geology accounted for 62.5 percent of the total female enrollment. By 1979 the three most popular majors--geology, geophysics, and chemical and petroleum refining--enrolled 48.2 percent of the women. The three least popular majors saw total female enrollments rise from 2 percent to 10.2 percent. Mathematics, the most popular major in 1970, dropped to next-to-last by 1979, while geology rose from second to first in popularity. Mining and petroleum engineering, which had no female majors a decade ago, now enrolls 15.8 percent women.

While women amount to 15.8 percent of enrollment, they vary considerably from major to major. Female chemistry and math majors now constitute 35 percent and 29 percent of the declared majors, whereas a decade ago their respective shares were 9.6 percent and 9 percent. In chemical and petroleum refining the number of women enrolled in-

Table 23

ANNUAL REPRESENTATION BY WOMEN WITHIN UNDERGRADUATE ENGINEERING PROGRAMS AT COLORADO SCHOOL OF MINES 1970

	# of Women		% of Women In Major		Women as % of Major	
	1970	1979	1970	1979	1970	1979
Basic Engineering	-	18	-	5.3	-	13.6
Chemistry	8	22	16.7	6.4	9	35
Chemical and Petroleum	3	62	6.2	18.1	2.3	19
Geology	9	63	18.8	18.4	5.7	22.4
Geophysics	4	40	8.3	11.7	3.4	20.5
Mathematics	13	12	27	2.9	9.6	29
Mining	0	22	0	6.4	0	7.5
Metallurgy	1	26	2	7.6	.7	17.6
Petroleum	0	32	0	9.4	0	8.5
Physics	3	7	6.3	2	3	8.7
Undecided	7	38	14.6	11.1	3.4	16.6

creased some twentyfold. In absolute terms, petroleum engineering has experienced booming popularity with women, rising from no majors in 1970 to 32 majors in 1979, making it the fourth most popular major among the women.

Performance and Attrition

Interviewees commented on (1) a historical tendency for women to outperform men, as measured by grade point averages and graduation, and (2) the apparent decay of this superior performance. Limited data support both positions. Among those students entering in 1970 who have either graduated or are still in school, 54 percent of the women had grades of 3.0 or better, compared to 31 percent of the men. Even more dramatic is the finding that 31 percent of the women had a grade point average of 3.6 or better, against 5 percent of the men. Given the small base, these percentages should be treated with caution, but they certainly support the idea of significant differences between the two groups. Furthermore, 48 percent of the males entering with the class of 1970 terminated or dropped prior to graduation, as compared to 32 percent of the women. Of those leaving school, 57 percent of the men and 33 percent of the women had a grade point average of 2.0 or below. These findings are generally supported by data from the class entering CSM in 1971. Fifty-one percent of males leaving prior to graduation have grade point averages of 2.0 or worse, while only 15 percent of the females leaving had grades below 2.0. Data for the years 1970 and 1971 suggest women staying at CSM were high achievers who, if they decided to leave the institution, did not do so for academic reasons.

Data from the class entering in 1975 show a profile consistent with a decline in exceptional performance by the women. Thirty-six percent of the women and 72 percent of the men leaving school before graduation had a grade point average of 2.0 or less. Women with grade point averages of 3.0 or better upon graduation dropped from 54 percent to 24 percent. Males graduating or still in school showed 34 percent with 3.0 or above. It appears that over a five-year period, the performance level for women declined notably, although the decline would not be predicted from the ACT and grade point average data discussed earlier.

Placement

Of approximately 9,000 graduates during CSM's first century (1874-1974), about 40 were women. By 1979 the number of female graduates had more than tripled, as women rose from 2.8 percent of the 1973 graduating class to 10.3 percent of the class of 1979. Systematic data on placement by sex are unavailable, but the CSM Placement Office reports no problem placing women. Employer experience with the high quality of CSM women has a beneficial effect, and some employers respond to affirmative-action pressures by specifically asking for minority or female job candidates. Women have enhanced their marketability by concentrating in areas with high employer demand. Of the 50 female engineering graduates in 1978 and 1979, 25 took degrees in metallurgy or refining engineering. Placement Office records show nearly twice as many job offers as candidates in these fields during this period, and placement personnel believe women did as well, if not better, than their male counterparts in finding employment. Entry-level salaries for CSM graduates averaged $1,652 monthly in 1979, ranging from $1,418 in basic engineering to $1,830 in petroleum engineering.

Factors Influencing the Enrollment of Women

Attitudinal Change

Since the late 1960s, there have been substantial changes in both women's views of engineering as a career and in broad acceptance of women as engineering professionals. Several interviewees noted a rising level of confidence in their technical capabilities and a growing number of role models encourages young women to think of engineering rather than traditional service positions or the "helping professions." As women think in terms of a career rather than short-term employment until settling down to raise a family, the demands of engineering training seem less burdensome. Not only have women found engineering to be attainable and satisfying, but on the whole, employers have found them to be productive professionals. Attitudinal change is especially important in energy and minerals engineering, as occupations such as underground mining or petroleum exploration have traditionally been regarded as male bastions. While there are still exceptions and reservations, observers appear to believe broad social change and demonstrated performance have opened long-term prospects for women in engineering.

Government Pressure

There is little doubt that affirmative action and equal opportunity requirements have expanded engineering employment for women. As noted earlier, some employers have approached the CSM Placement Office with specific requests for women or minority candidates. The shortage of female engineers in mineral engineering not only bids up salary levels but assures women in the area of engineering favorable job prospects for some time to come. The dependence of energy and mineral companies in the West on federal lands and leases may increase company sensitivities to AA/EEO compliance guidelines. Reportedly, some companies are using recent female graduates of CSM as recruiters in succeeding years as a means of "passing the word" on employment conditions to graduating women.

Job Opportunities

Massive investments in energy exploration and development have created a high demand for engineers which, when coupled with government pressures mentioned above, have pushed starting salaries and advancement prospects to extraordinary levels. While most starting salaries for new B.S.-in-engineering graduates ranged between $1,600 and $1,800 monthly, a few offers reached $2,500. Such salaries and attendant working conditions are in stark contrast to social-service salaries and the uncertainties of public-sector employment. Advancement to supervisory or management positions should come rapidly for women in mineral engineering. It appears that the job opportunities are so good it is difficult to persuade women to consider graduate training and teaching as part of their futures.

Program Vitality

The three factors listed above are "external" in the sense that they are independent of what happens at the university level. Internal factors also carry considerable weight, however, and among the most important of these is program character and vitality. Unlike institutions offering programs in civil or electrical engineering, CSM competes for students with a rather small number of institutions specializing in mineral engineering. Thus once a student decides on a mineral engineering field, the range of choice is rather restricted. Furthermore, CSM has a reputation for applied rather than theoretical engineering, increasing its attractiveness to students anticipating a career in industry. The distinctive character of the program and its high reputation in essence sells itself, drawing women as well as men from all over the country. Not only does enrollment at CSM offer a woman access to a strong program, but is not, as one student pointed out, "silk-collar engineering"--meaning it is not theoretical or laboratory engineering.

Recruitment

While CSM is enthusiastic about the quality and performance of its women students, it has not institutionalized an extensive recruitment program specifically to boost the number of women on campus. Recruitment programs are targeted to men and women, with much of the recruitment of women handled in a one-on-one or word-of-mouth basis. The character of the program precludes taking large numbers of students with an ill-defined interest in engineering, so shotgun recruiting tactics are not very useful. Alumni and practicing engineers apparently play major roles in steering would-be mineral engineers to CSM. While one would not describe the recruitment of women as passive, CSM does not display the aggressiveness in recruiting women which some institutions do.

Institutional Culture

A key element in recruiting and retaining women students is what might be called "institutional culture," the assorted practices and attitudes which shape day-to-day life on campus. In a broad sense, institutional culture appears very supportive, although not necessarily in a dramatic fashion, of an expansion in the number of women engineering students. Interviewees report general willingness on the part of administrators to enhance CSM's attractiveness to women, although they hesitated to single out more than one or two administrators for whom this is a priority issue. One approach to making the institution more responsive to women has been the development of activities more closely aligned to their interests. On-campus housing has been remodeled and expanded to accommodate women, intercollegiate athletics for women are entering their fourth year, and two sororities have initiated operations. A chapter of the SWE was formed in 1970 to sponsor professional development activities such as conferences and career guidance.

One important point on institutional culture relates directly to the issue of "women-oriented" programs for student recruitment and retention. Some interviewees commented that many women see themselves as engineering professionals first and women engineers second. They are reluctant to involve themselves in activities geared solely to women, but rather put their energies into student branches of professional societies or other organizations which do not call attention to them as social curiosities on a male-dominated campus. This view is not universal, and several interviewees mentioned the need for more women role models and for stronger support systems among women. Only five of 178 regular teaching faculty in fall 1979 were women, and there are only 8 to 10 professional women in other campus positions, including administration or senior library staff.

Financial Support

The distribution of financial support by sex was not available. The Financial Aids Office reports approximately 25 percent of the undergraduate enrollment receives annual assistance averaging $1,430. Women apparently do very well in competition for funds, although most are allocated on need, rather than sex or other basis. There are few awards specifically for women, but some industry donors reportedly have increased their support, requesting CSM to give special attention to worthy minority or female applicants. Sources of financial assistance include five federal programs, three state programs, institutional grants and loans, and more than 70 private scholarship programs. Industry support for CSM students is reflected in the more than 50 scholarship funds bearing the names of corporate or professional society donors. Industry also provides support via cooperative-education and summer-employment programs. These programs are valuable not only for their financial utility, but because they offer opportunities for women to gain practical engineering experience.

Prospects

Although admissions officers doubt women will ever reach 50 percent of CSM undergraduate enrollment, they do not expect the increase in women students to plateau in the near future. Approximately 35 percent of the rise in enrollment from 1970 to 1979 may be accounted for by the growth in female enrollments. In 1979, 22 percent of the entering class were women. Continuing favorable prospects for employment and growing acceptance of women engineers and engineering as an acceptable field for women will attract additional students.

A greater concern may be student retention. Of 19 women entering in fall 1971, 7 or 37 percent left prior to graduation. Attrition among women entering in fall 1979 rose to 46 percent. This may reflect a decline in capabilities, although this is not reflected in admissions qualifications data, or it may reflect a decline in motivation. Some interviewees suggested that in spite of the tendency to treat women as "one of the boys," they have specific needs which could be addressed more creatively. There may be a need for more effective support systems. Also, it is unclear whether women leaving CSM are leaving engineering or transferring to other engineering schools.

Generalizability of Findings

One suspects that findings from the CSM case study may have certain comparabilities to other institutions. The influence of equal employment opportunity and affirmative action programs on employer hiring practices impact across engineering. Changing societal attitudes are also likely to generate an upward trend in female enrollment in engineering. Institutional responses may vary from aggressive recruitment of women to more passive acceptance and accommodation.

While CSM may be broadly comparable, two distinctive features set it apart from many other institutions. First, it does not exist as part of a larger university, but stands alone. This means that many of the attractions, and distractions, of a large university setting are absent. It would be interesting to know how many women may transfer to other institutions for reasons of institutional environment. Second, CSM has a relatively narrow focus: energy and mineral engineering, rather than the multiple engineering programs found in larger institutions. Women deciding they would prefer careers in other fields of engineering, such as civil or electrical, must transfer. Any comparisons, therefore, should take into account the distinctive character of CSM.

PRAIRIE VIEW A & M UNIVERSITY

The College of Engineering

Prairie View A & M University is a coeducational state-assisted institution and land-grant college. A member of the Texas A & M University system, it is located in Prairie View, Texas, approximately 45 miles northwest of Houston. The school was founded by constitutional mandate in 1876 to serve black students of the state of Texas.

The College of Engineering, established in 1949, offers major degree programs in architecture, civil engineering, electrical engineering, and mechanical engineering, all of which are at the bachelor's level. The Board of Regents has also approved new degree programs at the undergraduate level in chemical engineering and industrial engineering and a master's program in engineering.

Enrollment Patterns

In 1979-80 enrollment in the College of Engineering was 814, which represents a 13.7 percent increase over the 1978-79 figure. The increase for entering students is even higher: the 1979-80 freshman class consisted of 326 students, compared to 259 students in the 1978-79 freshman class, a difference of almost 30 percent. Of the total 1979-80 enrollment, 218 (or 26.8 percent) are women. In all, the last seven or eight years have witnessed a 300 percent increase in total enrollment. As with other case study schools, Prairie View began to show an increase in the enrollment of women in 1973. Today women constitute

218 or 26.8 percent of the students in engineering.

Because of the kind of students Prairie View recruits and attracts--those with low socioeconomic backgrounds--it does not place the same emphasis on entrance requirements as do other schools. Admission to the College of Engineering is a flexible and personalized process, based on an assessment of students' attitudes about themselves, their desire to achieve, performance in high school, social involvement, and willingness to help others to achieve. These attitudinal factors, rather than an exclusive emphasis on the traditional instruments of admission, are important measures for admission to the College of Engineering.

Women engineering students at Prairie View enter the College with relatively strong academic backgrounds. They usually rank in the top 10 percent of their high-school classes, with grade point averages of 3.5 or better, and list their favorite high-school subjects as science and mathematics. Their college grade-point averages are equivalent to those of male students.

The offices of the Dean of Engineering and Career Placement and Planning report that women students have a 100 percent placement rate. Unlike those of other institutions, women graduates of Prairie View earn somewhat less than male graduates, with entering salaries ranging from $18,500 to $21,000.

The women students seemed to cluster in the area of mechanical engineering as a specialty. Although the majority of women engineering students come from Houston, the nearest metropolitan area to the campus, the number of out-of-state students is increasing.

In addition to the regular government (state and federal) grants, women students are eligible for special merit scholarships provided by the University and special grants from industry. There is no special financial aid program for women.

Factors Influencing the Enrollment of Women

External

At Prairie View, as with other institutions, several external factors were cited as contributing to enrollment growth among women in the School of Engineering. Prairie View was involved in the efforts of General Electric and The Sloan Foundation in the early 1970s to increase the number of minorities in engineering. These were joint efforts between a selected number of engineering-school deans and industry representatives. The feeling at Prairie View is that black women benefited primarily because they were members of minorities, not women, and that nothing special was done in the way of recruitment, financial aid, or academic support to recruit or retain women students in engineering.

General recruitment efforts, however, have been strengthened through the networks that the College has developed with high-school counselors, teachers, and alumni. The image of the College in the communities from which the target audiences come seems to be positive. Prairie View has a reputation of having a good engineering program, a high success rate for students who come from low socioeconomic backgrounds, and the ability to create an atmosphere in which students of the minority population are motivated, encouraged, and assisted.

Industry support is apparently a major factor in two programs that are regarded as important to stimulating the growth of engineering enrollments at Prairie View--Project MITE (Minority Introduction to Engineering) and the Engineering Concepts Institute (ECI). MITE is a 2-week summer engineering awareness and orientation program for eleventh- and twelfth-grade students. In the summer of 1979, three such sessions were held at Prairie View, each attended by about 50 students. They became aware of MITE through routine recruitment efforts at high schools and through high-school counselors. ECI is an intensive 10-week summer program for recent high-school graduates--a "readiness" program for engineering study in which the student earns academic credit toward an engineering degree. There were 185 ECI students in the summer of 1979.

Internal

Because of its clientele, Prairie View has established several support programs to ensure the success of most students who are admitted to its programs. Though these programs are designed for minority students who might need special assistance--not specifically for women--women can also benefit from them.

An Assistant to the Dean, although a male, approximates the role of counselor for women students in his capacity as faculty sponsor for the Society for Women Engineers. In addition, tutorial help is available to all Prairie View engineering students through

"Project Intercept," which is designed to improve academic performance and retention. Other programs, such as peer counseling and tutoring services for students in engineering, as well as early-alert systems, also contribute to Prairie View's high retention rate.

Summer support programs include two 10-week programs: the Engineering Foundation Institute (EFI), which is designed to improve the performance of marginal students believed to have potential for higher achievement, and the Engineering Science Advancement Institute (ESAI), a program for high-ability engineering students. Another special program, Project SEE, provides relevant summer engineering experience to engineering majors through assignments in industry and with governmental, consulting-engineering, and architectural firms. Project SEE is distinct from cooperative education projects under which students either work for a semester or a year during an extended engineering program.

Prairie View, being a residential institution, is able to provide an environment which permits total involvement of its students (academic and nonacademic) on an around-the-clock basis. Intensive and extensive effort is placed on developing the whole student because the University recognizes some of the nonacademic inadequacies of its entering students and sets out to correct most, if not all, of them.

Prospects

It is the feeling of Prairie View's officials that increases in the enrollment of women will continue in the College of Engineering until women constitute about one-half of the student enrollment. The percentage of women in engineering, they believe, will probably reflect the percentage of women in the University as a whole. The University plans to establish no special women's program in recruitment, curriculum, or retention. Its philosophy is that these students, because of their backgrounds, have experienced enough isolation and separation from the main culture. Such an effort would go counter to what the institution is attempting to do in "mainstreaming" its students.

The average enrollment of women at Prairie View seems to be at the 50 percent level. The University's programs, yearbooks, and other publications indicate that the presence of women on the campus is very noticeable--particularly in that they hold several student offices. Recently a woman honors student in engineering was appointed cadet commandant of the R.O.T.C.

It appears that Prairie View's efforts to recruit minorities has, for no identifiable reason, attracted a considerably larger-than-average number of women students. The impression at Prairie View is that the women are about equal to men in high school preparation, in motivation and ability, in performance at Prairie View, and in retention.

Because Prairie View's policy is one of open-door admission, it can be argued that black women are less likely to be denied admission than white women because the University does not rely solely on the same criteria for admission as other institutions. The success rate of graduates and job placement support the contention that students at the University do not suffer from the absence at Prairie View of these traditional requirements. Like other schools with a similar mission, role, and scope, Prairie View continues to assert a greater interest in exit requirements than entrance requirements, which have proven to be barriers to minority advancement in higher education and the professions.

Generalizability of Findings

Prairie View is distinct from the other case-study schools in that all its programs are geared to the needs of minorities and those otherwise disadvantaged. A high-school certificate is the only academic qualification for admission. The assumption is that if SAT scores or class ranking were used as admission criteria, the disadvantages experienced in high school would only be perpetuated. Prairie View is distinct also in that it is, in effect, a highly segregated school. Although it does not seek this degree of segregation, Prairie View does not apologize for its heritage as a black university. In any case, a black woman in engineering should not have the same problems with cultural or racial bias that she would encounter in a predominantly white institution. Perhaps a case can be established that a black woman's performance at Prairie View can logically be compared to a white woman's performance elsewhere.

In effect, Prairie View is an open-door institution for all its programs--although administrators do not use that term. In engineering, undoubtedly, the MITE and ECI programs function somewhat as a selection mechanism, but the formal position of the school is that it does not seek "better students" as identified by conventional indicators. Prairie View engineering students are screened, however, to make sure that they are prepared for the discipline of college work and have well-established goals. Apparently, these subjective criteria are commonly used in engineering, medical, and other professional schools to satisfy the demands of the professions for highly motivated, personally competitive, work-oriented students.

If Prairie View is distinct in its admissions policies and objectives, it also seems to be distinct in its extensive effort to give students tutorial support and to identify their academic problems quickly. This is clearly part of its general strategy to help students overcome their early disadvantages so that they can catch up during their four years at Prairie View and emerge with a professional competence that meets the needs of engineering employers. Since Prairie View claims a high placement rate--100 percent for women engineering graduates--it apparently succeeds in its ambitious aim.

NEW MEXICO STATE UNIVERSITY

The College of Engineering

Originally named Las Cruces College after the city in which it is located, New Mexico State University (NMSU) began its first classes in 1888 and granted its first baccalaureate degree in 1894. Other changes in its name over the following 72 years indicate its land-grant origins: New Mexico College of Agriculture and Mechanic Arts (1889) and New Mexico State University of Agriculture, Engineering, and Science (1958). Both of these former designations reflect the emphasis that the University has traditionally placed on its engineering programs. Nevertheless, NMSU offers a varied group of academic programs within its five colleges--Arts and Sciences, Agriculture and Home Economics, Education, and Engineering--in addition to a requirement that engineering students take 18 credits in the humanities and social sciences.

The location of the College and University in the far Southwest has given both a distinctively high ethnic composition: About one-fourth of the students at the University and in the College of Engineering are Hispanic. In comparison, relatively few blacks and other minority students are enrolled in the College, but the efforts of an associate dean in the early 1970s led to a more active program of minority recruitment. At the same time, the College began working to increase its enrollment of women. As might be expected, the representation of women by ethnic group corresponds generally to the representation of men, though the actual numbers of women are considerably smaller. In fall 1977, for example, 20.3 percent of the women students were Spanish-surnamed (n=40) against 25 percent of the men (374); 3 percent were black (6) against 0.8 percent men (13); and 1.5 percent were Native American (3) against 1.6 percent men (25). White women accounted for 75 percent of the female undergraduate enrollment (148) and white men for 72.5 percent of the male enrollment (1,097).

The College of Engineering at NMSU offers eight engineering programs for the Bachelor of Science degree: agricultural, chemical, civil, electrical, geological, industrial, mechanical, and engineering technology. In addition to its basic requirements for graduation, the College encourages its students to participate in a cooperative education program following two semesters of introductory academic work. In some cases, cooperative education experience may be applied to credit for professional registration in the state.

Out of a faculty roster of approximately 74 regular or tenure-track positions, no women hold faculty appointments at present, nor are there any women among the ranks of visiting professors, adjunct professors, research associates, or instructors.

Enrollment Patterns

The enrollment of women in NMSU's College of Engineering has increased steadily over the past four years, even though the rate of increase has not been consistent. In 1976, the first year for which data on women's enrollment are available, the College enrolled 141 women, or nearly 10 percent of its total undergraduate population of 1,510 (table 24). In 1979, women constituted 14 percent of the College's total enrollment.

Despite this overall growth in the proportion of women students, however, figures for selected years (table 25) show that fields in which women constitute the highest percentages--industrial engineering, geological engineering, and chemical engineering--are among the smallest in total student enrollment. By the same token, fields in which women constitute lower percentages of enrollment--electrical engineering, civil engineering, engineering technology, and mechanical engineering--are among the College's largest. This inverse ratio might well be explained, as it is elsewhere, by the fact that the introduction of a relatively few number of women into smaller programs can more dramatically increase their proportional representation. Rather than looking at percentage gains to determine the interests of women in specific engineering programs, therefore, it may be more useful to examine the representation of women in the largest fields--those in which a particularly sharp increase or decrease would indicate an unusual pattern of vocational or professional interest. Of the four largest areas of study at NMSU, however, enrollment percentages for women in 1979 show little variability. Perhaps by accident, they also correspond closely to the ranking of each course in terms of total numbers of students. Furthermore, the percentage increase of women in these areas in the College over the two-year period 197701979 has been relatively stable,

Table 24

New Mexico State University College of Engineering

Annual Undergraduate Enrollments 1976-1979

Year	Number Men	Number Women	Annual Increment in # of Women	Total Undergrads	% Women	Annual Increment % Women
1976	1,369	141		1,510	9.3	
1977	1,513	197	56	1,710	11.5	2.2
1978	1,635	235	38	1,870	12.6	1.1
1979	1,773	288	53	2,061	14.0	1.4

Source: Office of the Dean, College of Engineering, New Mexico State University, 1980.

Table 25

Undergraduate Enrollment by Engineering Program

New Mexico State University

1977 and 1979

	1977			1979		
	Total Undergrads	# of Women	% Women	Total Undergrads	# of Women	% Women
Electrical Engineering	459	56	12.2	574	78	13.6
Civil Engineering	349	31	8.9	385	47	12.2
Mechanical Engineering	315	21	6.7	366	36	9.8
Engineering Technology	254	25	9.8	338	36	10.6
Chemical Engineering	168	41	24.4	201	47	23.4
Industrial Engineering	88	16	18.1	90	26	28.9
Agricultural Engineering	44	2	4.5	31	3	9.7
Geological Engineering	26	5	19.2	32	8	25.0

Source: Office of the Dean, College of Engineering, New Mexico State University, 1980.

with the exception of women's enrollment in civil engineering, which rose about 3 percent.

In comparison to the national average for these areas in 1977, the percentage of women students differed most remarkably only in electrical engineering, with women at NMSU representing 12.2 percent of the students enrolled in the program against the national average of 5.5 percent. This high representation of women in electrical engineering at NMSU might suggest that the reputation of the program, local industrial incentives or influences, or government programs at the school were making women more aware of this field as a career possibility.

Factors Influencing the Enrollment of Women

External Factors

NMSU administrators and faculty who recently were interviewed observed that five environmental factors have affected women's enrollment at the University: industry support; changes in attitudes of young women recently graduated from high school with regard to engineering; federal government intervention; high-school preparation and counseling; and the image of the College of Engineering.

Industry support. Most colleges of engineering are closely tied to industries that employ many engineers. The College of Engineering at NMSU is no exception. The influence of industry on women's enrollment in engineering at NMSU has occurred in several forms. First, industry has provided funding for scholarships to women students through the Designated Academic Opportunity Scholarships (DAOS). Currently funded at about $40,000, DAOS provides support for about 65 students annually.

Second, industry sponsors women students in the cooperative education program, which offers to students work experiences in engineering fields and later, upon graduation, entry into industry jobs. Third, industry provides summer employment opportunities for women students who want or need financial support and additional work experience. Fourth, industry actively recruits women engineering graduates from NMSU. When these forms of influences are considered with overall employment opportunities and salaries, industry's influence on women's enrollment in engineering is perhaps the most significant of any one factor.

Attitude change of women toward engineering. Attitude is a difficult factor to describe and measure. However, each of those interviewed at NMSU indicated the importance of a perceived attitude change toward women enrolling in engineering. One described the general attitude change as "a revolution in what women think they can and ought to do." Several others noted that women high-school graduates have changed in their outlook and preparation for careers. In particular, women increasingly have become aware that engineering jobs are available and offer competitive salaries. One faculty member observed that engineering has become a more socially acceptable profession for women, encouraged by more professional role models of women in engineering positions and by a "critical mass" of women students in engineering. The interviews also indicated that the influence of parents and high-school counselors on the attitudes of women toward engineering had affected women's enrollment in engineering at NMSU.

NMSU faculty and administrators identified attitude changes and industry support as the strongest external forces affecting women's enrollment at their University.

Federal government interventions. The most direct influence of the federal government on women enrolling in engineering at NMSU is through a financial-aid program called the Corporation for the Advancement of Experiential Learning Programs (CAELP), which provides about $80,000 to support approximately 45 students annually. In addition, students may receive financial assistance through other federally sponsored programs. The federal government also has funded indirectly the enrollment of women in engineering at NMSU. In 1973-74, the National Science Foundation (NSF) awarded a grant to NMSU to demonstrate the use of minicomputers to students at the junior- and senior-high levels in the state. These computer demonstrations introduced students to the uses of math in engineering.

Two current federally sponsored projects--one funded by NSF to operate the Southwest Resource Center for Science and Engineering, and the other, funded by the Department of Health, Education, and Welfare (HEW), to attract women into engineering doctoral studies--could also promote additional enrollments of women in engineering. Finally, affirmative action and compliance guidelines of the federal government were perceived as instrumental in encouraging industries with federal grants to hire women.

High-school academic preparation. High-school academic programs in mathematics and the sciences are essential for adequate preparation to enter engineering programs. Although data were not available, several interviewees commented on the excellent math and science backgrounds of women entering the NMSU engineering program and attributed their preparation to high-school programs.

Image of the College of Engineering. Students wishing to attend an engineering school in the state of New Mexico have three choices: the University of New Mexico (UNM), New Mexico Institute of Technology, and NMSU. While about an equal number of students select UNM and NMSU, faculty and administrators at NMSU believe that the College of Engineering at NMSU has an excellent in-state and regional reputation for its programs, faculty, and students. The NMSU College of Engineering is accredited by the state and national associations and appears to be especially attractive to those students who want to complete a bachelor's degree and enter the job market.

Internal Factors

Six activities and characteristics of the College of Engineering at NMSU were mentioned as influential: recruitment, special programs for women, positive faculty attitudes, administrative leadership, University support of the College of Engineering, and professional associations represented in student organizations.

Recruitment. The College of Engineering, in consort with the universitywide recruitment and admissions offices, conducts a number of special recruitment activities for women. A full-time counselor in the College of Engineering works with universitywide recruiters to visit high schools, prepare and distribute brochures and posters, and to host parents and students in visitation days and summer conferences. Of all the special programs for women sponsored by the College of

Engineering, recruitment is viewed as the most essential to creating awareness and interest among prospective women students.

Special programs for women. The College of Engineering offers three financial-aid programs and as many special activities, which are considered instrumental in enrolling women students in engineering. The three financial-aid programs are: DAOS (industry-sponsored); CAELP (federally sponsored); and the National Fund for Minority Engineering Students. During the summer, the College of Engineering offers a one-week conference for students between their junior and senior years of high school. These conferences are supported by the Minority Introduction to Engineering Program (funded through the Accreditation Board) and the American Indian High School Orientation Program (funded through a special state appropriation). Two additional special programs, funded by the NMSU Foundation, are the Tutoring Program and the Crimson Scholar Honors Program. These programs are designed to reach the most academically deficient and gifted, respectively. In combination, these special programs provide a range of resources perceived as helpful to prospective women students.

Positive faculty attitudes. Several persons in the interviews mentioned the positive faculty response to women students, who are perceived by faculty as highly motivated, capable, and competitive. One interviewee described the women students, as a group, as "over-achievers, successful in high-school academics, and leaders in high-school organizations." Once enrolled in the engineering program, women students are perceived as achieving higher grade point averages and having a lower attrition rate than men. NMSU faculty report that they are extremely pleased with the high quality of women students, an attitude apparently reflected in special recruitment programs and student activities directed at increasing women's enrollment in engineering at NMSU.

Administrative leadership. The initial impetus for enrolling women students in the College of Engineering reportedly came from the interests of an associate dean who initiated some of the special programs for women students. Development and continuing support of these efforts is attributed to the present Dean, with the support of department chairpersons. One interviewee observed: "Funding for activities and support with industry requires high-level administrative leadership. The programs for women would still function without this level of leadership, but not at the same caliber."

University support. In addition to the support from the faculty and Dean, special programs for women in engineering at NMSU are enhanced through the support of universitywide administrators. The College of Engineering appears to be in a favorable position with the University administration because of its success in attracting students, industry support, and outside funding for research.

Ties to professional associations. Through 15 student organizations and a chapter of the Society of Women Engineers (SWE), the College of Engineering has ties with a broad range of engineering professional associations. These professional associations contribute both direct and indirect support to women in engineering programs. Over half of the women students belong to one or more of these organizations, and women are the elected leaders in a majority of these student organizations. The SWE chapter has declined in importance relative to the other student organizations. It is not clear to what extent these student organizations influence enrollment or retention of women students.

Prospects

While interviewees generally agreed on the external and internal factors affecting women's enrollment in engineering at NMSU, their views about future enrollment trends for women were disparate. Some believe that over the next decade, the percentage of women will equal that of men in engineering at NMSU. They assume that the engineering job market will continue to flourish, that the pool of potentially qualified women students will be large, and that NMSU will continue to recruit women students. Others expect the percentage of women in the engineering program to level off quickly or even decline, relative to men. They believe that efforts by industry to recruit and support women in engineering will decrease and that the pool of qualified women high-school graduates will not grow substantially (in fact, they anticipate a declining pool of all high-school graduates). In addition, they note that NMSU is not likely to attract those women students who wish to go out of state or to a more prestigious university. Still others believe that by 1990, women's enrollment will constitute about one-third of total enrollments in engineering. This projection reflects a moderate position that combines elements of the other two viewpoints.

The College of Engineering at NMSU does not intend to sacrifice quality for enrollment increases of men or women. If the numbers of qualified women students bound for engineering--those who are interested in engineering and have adequate preparation in mathematics and science to meet the university admissions criteria--are not substantially increased, then attracting and retaining increasing numbers of women in engineering programs will be difficult. An important issue focuses on the question: Can an average woman student be an engineer? If NMSU enrolls only those with strong backgrounds in math and science, the pool of available students would seem restricted. The pool of prospective students could possibly be enlarged by working with high schools to increase the number of women with math and science backgrounds. Another option would be to admit greater numbers of women students with less math and science preparation.

Generalizability of Findings

New Mexico State University (NMSU) is primarily an undergraduate institution serving a sparsely populated state. Students at NMSU in engineering intend to enter full-time employment after obtaining the bachelor's degree; few enter graduate programs in engineering. In the judgment of those interviewed, the strategies used to attract women into engineering at NMSU would not be transferable in reaching minority groups. While minority programs attract women as well as men, a different set of issues and student backgrounds apply to minority populations when compared to majority white women.

7. AN ANALYSIS OF THE CASE STUDIES

The clearest, if somewhat platitudinous, inference to be drawn from the foregoing institutional case studies is that the upsurge in enrollments of women in engineering programs during the seventies had a number of causes, deriving from both external and internal conditions and factors. External causes seem to have predominated. Moreover, the participation of women in engineering education and in the profession seems paradoxically to have been given much impetus by a depression in the engineering job market in the late 1960s.

The predominance of external influences should not be taken to mean that internal forces and efforts at the case-study institutions, and by extension at many other colleges and universities offering engineering programs, were in any way superfluous or lacking. Indeed, we found almost no indication of heel-dragging or outright indifference to the aspirations of women to become engineers. Rather, this trend generally was welcomed and facilitated and its continuance is regarded as a sanguine prospect. Nevertheless, it seems doubtful that women could have entered engineering schools in such numbers so quickly purely as a result of institutional efforts.

External Factors

The most potent external factors operating to increase the enrollment of women in engineering programs over the past decade would seem, on the basis of the case studies, to be the following:

- Job market outlook for engineers generally and opportunities and competitive salaries for women in particular

- Industry recruitment of women for engineering positions and industry support of engineering-education programs through funding of scholarships, co-op programs, summer employment, and campus career institutes for prospective students
- A change in the image of engineering as a field now central to public-policy and environmental issues
- A change in society's attitude toward women's roles in the work force and the consequent change of women's attitudes and awareness regarding engineering as a career

In addition, at least secondary importance can be assigned to the following perceived external factors:

- Federal financial-aid programs for students
- Affirmative-action pressure on industry
- High-school teachers and counselors encouraging students to acquire academic backgrounds and interests relevant to engineering studies
- Parental and family influence on the role perceptions of women students and their choice of college or university

These external forces do not operate in isolation in the environment that influences engineering enrollments. Rather they interact synergically to create both constraints and opportunities. Similarly, schools and colleges of engineering, as well as the institutions of which they are a part, are lodged in a complex network of formal organizations that influence each other. Some of these organizations are more tightly coupled than others. Engineering schools have close relationships with employers of engineers and with their so-called "feeder" high schools--that is, high schools that traditionally send a relatively large number of students to the college or school of engineering. Both these couplings are rather tight. By contrast, the coupling between engineering employers and high schools is loose.

Internal Factors

The strongest internal forces acting to increase enrollment of women in engineering programs appeared to be:

- Enrollment decline, either real or expected, creating new awareness of women as a potential new pool of students
- Recruitment efforts aimed at making women high-school students aware of opportunities for them in engineering
- Persistence of efforts to increase the number of women in engineering programs, sometimes with leadership exerted by other than individuals placed high in the formal organizational structure
- Support from administrators combined with an at least benign faculty attitude
- Designation of responsibility for coordinating efforts to attract and support women in engineering programs
- Student organizations providing social support and professional affiliations for women students in engineering--the most active not necessarily being the campus chapter of the Society of Women Engineers

- Scholarships for incoming and returning women students in engineering--not always designated as scholarships reserved for women and not always of large amounts, but serving important means of recognition and psychological support
- Retention activities directed to the particular needs of women students
- Location of the institution

It is important to note that many of these efforts were not specifically intended to help women. Often they stemmed from active recruitment of students, which previously had not been necessary. However, the prevailing societal forces made larger numbers of women more likely to take advantage of them, because:

- They were high achievers in high school
- They came from families and socioeconomic backgrounds such that a choice of an engineering major was a relatively minor shift from a choice of science or math in college, which they might otherwise have made

Thus relatively low-level recruiting efforts could have a large effect in generating women's enrollments. The recruitment of minorities proved to require a greater effort, since it often involves creating in students who might otherwise not attend college an aspiration to complete a demanding program in college. The particular coincidence of the efforts of engineering schools to recruit more students and the readiness of more women to entertain nontraditional careers probably explains why many schools felt that the increase in women appeared to "just happen," without extraordinary effort on their part.

Beyond these main factors identified by those interviewed at the case-study institutions, other, more subtle influences seemed sometimes to be present. First, reference often was made to information about engineering students. For example, SAT and ACT scores were frequently mentioned, as well as retention rates, and grade point average.
In some cases, special data sets and data sources were mentioned: at Vanderbilt, for example, internal transfer data was closely examined and at Purdue the College Board Search Service was used to identify prospective women engineering students. It is likely that available data and information about students, prospective students, and programs has contributed to positive perceptions about women in engineering programs.

Another subtle influence is the role played by various agencies and associations in influencing institutional responses to women in engineering. For example, the federal government not only provides direct financial aid to students, but also:

- Provides funds for research and demonstration projects that have given an impetus to women's enrollments in engineering (for example, the NSF and HEW grants to New Mexico State University and the Women's Education Equity Program Grant to Purdue University
- Enacts, administers, and adjudicates legislation that legitimizes support for affirmative action and puts pressure on industry to respond
- Contracts with industry to develop or produce goods and services that keep the job market for engineers favorable

- Compiles and publishes data that indicate the relative positions of women in engineering and the sciences

Professional associations exert more influence than by supporting student engineering organizations on campus. They also:

- Collect and publish data and research reports (Scientific Manpower Commission, American Association of Engineering Societies)
- Conduct national meetings, workshops, and publish newsletters and journals to express concerns about women in engineering
- Support information exchange networks and clearinghouses for research and exemplary practices on women in the professions (Women's Educational Equity Act Program Network)

A third point of consequence is that the increased enrollments of women in engineering programs has not required any fundamental curriculum changes in engineering or any modification of basic admission policies or quality standards.

Indeed, the expansion of the applicant pool by attracting higher competitive women has apparently helped maintain high overall admissions standards during periods of decreased enrollments. The main enterprise of engineering education has not been changed, either to stimulate or accommodate women students. Faculty resistance has not been an issue presumably because little or no change was required of most faculty. The large majority of the women entering engineering programs have been good students, and programs for recruiting and supporting them rarely threatened existing resources.

The composite picture formed by these case studies shows the institution reacting without resistance to a confluence of environmental forces conducive to the increased enrollment of women in nontraditional programs. In our cases, the enrollment numbers appear to reach a kind of critical mass that sustains momentum in an institutional environment in which women are no longer an exception. In other words, as the numbers of women increase, some of the barriers to women implicit in an environment where they are a small minority are lowered without conscious institutional effort (Kanter 1977).

The picture could have been different, resembling either of two extremes. On the one hand, we might imagine a less fortuitous situation in which potential legal conflicts threatened resources or particularly hardened attitudes toward women engineers led to resistance to the enrollment of women. Such barriers to potential women students might well have acted to keep their enrollment down despite supportive external forces. On the other hand, the institution might have taken a more proactive stance toward the enrollment of women. We would then expect to see female enrollments increasing at an earlier date than the national trend--as indeed happened at Vanderbilt.

Projections

Will enrollments of women in engineering continue to increase? Most of those interviewed for the case studies expected that enrollments would continue to rise at their institutions. But all agreed that it would be difficult to project the exact percentage of women in engineering programs 5 to 10 years hence. The most optimistic projection was 50 percent; the most conservative was 20 percent.

Most of those interviewed felt that special programs for women, especially recruiting efforts, would continue for some time, but eventually would disappear.

Some of the rationales provided in the cases for the predictions relate to many questions beyond the scope of these case studies. Some see the trend in women's enrollments as a product of a variety of environmental forces and expect a leveling off with increased attention by industry to minority hiring. Others, seeing a self-sustained momentum, expect no end to the trend until the percentage of women in engineering schools matches that of the population at large. Still others, viewing the trend as a product of institutional efforts, see it increasing so long as institutional commitment is sustained.

While our analysis suggests that many changes resulted from external environmental forces, we do not know that reduction of those forces will reverse the changes they influenced. Internal changes were real, and once occurring, may well endure: they produced internal changes in attitudes toward women engineers, created implicit support groups for future women students, and established an environment where women are no longer considered exceptions. We do not know, of course, how much of a self-sustaining effect these internal changes will have if supportive external influences should decrease.

Interest by industry appears to be slackening with regard to women in engineering. The interpretation by those interviewed is that affirmative action pressure is being directed at minorities and not at (majority) women. Because schools and colleges of engineering are closely linked to industries, the interests (and funding) of industry are reflected in engineering programs and support functions.

At the supply end, there is an implicit limit to the proportion of high-school students who can enter engineering programs, imposed by a four-year math requirement specified for entrance to most engineering schools. Traditionally, fewer high-school women than men have taken four years of math. As programs develop in the high schools to enable and encourage greater high-school math training for women (many provided by engineering schools), the number of qualified women will continue to increase. If circumstances cause this trend to level off, it will in turn affect the proportion of women entering engineering programs.

We selected for our case studies institutions at the leading edge, or at least above the national averages, of women's enrollments in engineering. However, we believe we have learned about conditions and practices that are applicable to most schools of engineering. The schools of engineering looked very similar in our case studies; the institutions looked very different. We believe that the main variables in transferability of findings among universities are those characteristics in the external environment to which institutions can respond.

With some modifications to a particular college of engineering, much of what we have learned about the recruitment strategies could be adapted to any target population. These general target populations could be majority women, majority men, minority women, minority men. Within these general target audiences, however, one would expect to find a wide range of variability; differences within groups may be as great as or greater than differences between these groups. While recruitment strategies may be similar, student motivations vary widely. Even with filtering criteria such as SAT scores or high school grade point averages or math background or interest in engineering, one would expect to find great differences in social backgrounds and perceived needs.

8. THE CASE STUDIES VIS A VIS NATIONAL TRENDS

In retrospect, the relative success of our case-study institutions in enrolling women in engineering programs appears to have been very much a product of a fortuitous confluence of national trends. The signs appear over and over in the cases. At a minimum, success was achieved because the institutions did not resist the influence of four largely external forces: (1) the changing role of women in the work force, (2) the response of industry to federal laws and regulations regarding affirmative action and equal opportunity, (3) the interrelated effects of the job market for engineers on enrollments in engineering programs, and (4) the changing image of engineering as a field central to societal improvement. As we have seen, nonresistance did not equate with passivity: institutional initiatives were not absent and not without effect.

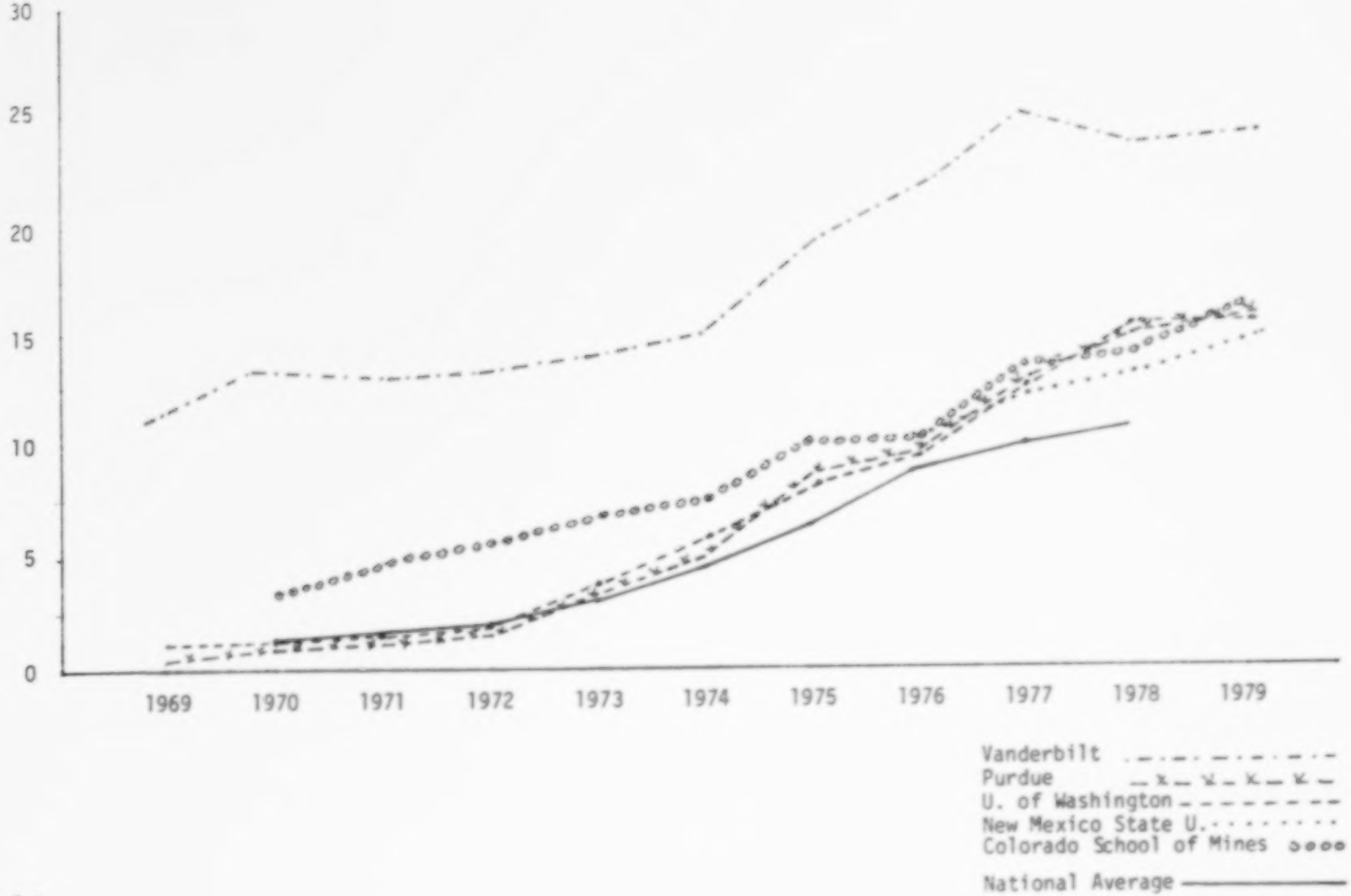
Given the interaction of so many factors, however, it is difficult to speak in terms of causality. Clearly, no single set of actions, nationally or institutionally, accounts for the increase of women in engineering. Instead, we think, a series of enabling factors acted together to create a situation in which the enrollment increases appeared to just happen. Here we will consider the six case studies in the context of these national enabling trends in order to understand more clearly their interactions.

If the percentage enrollment of women in engineering in five of the six schools is compared with national data over the past decade, a clear pattern emerges. As shown in figure 2, the trend lines follow remarkably parallel courses, and each begins to rise more steeply in

Figure 2

Women as a Percentage of Undergraduates

Annually Enrolled in Case Study Schools of Engineering



1972-73. Even at Vanderbilt, which began the decade with a considerably higher proportion of women than the other schools, subsequent increases in the proportion of women followed a similar pattern. (One could speculate that Vanderbilt got a head start because it turned coeducational and thus had an impelling reason to recruit women actively in the 1960s.)

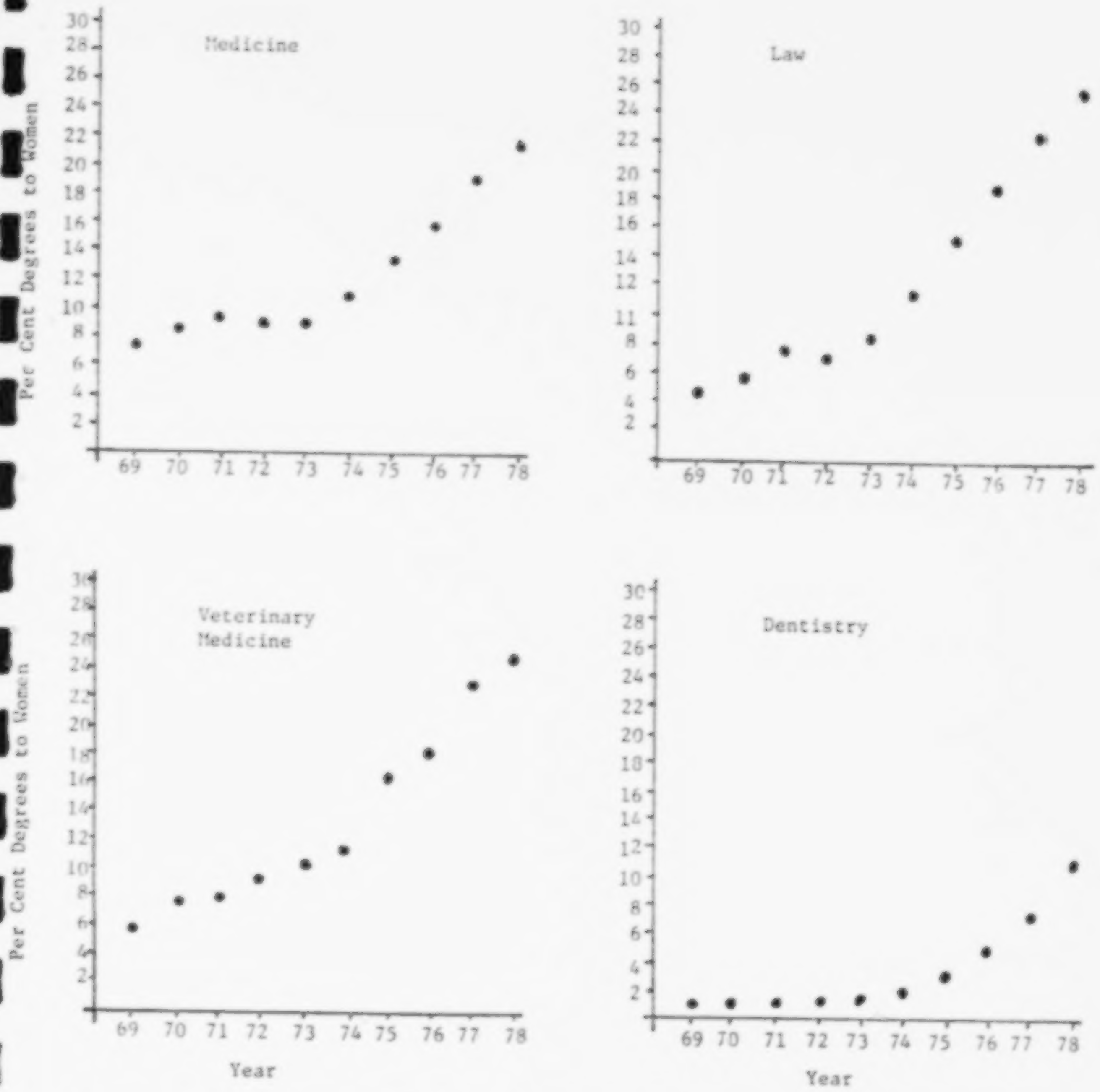
Female enrollment trends in engineering follow a pattern that holds true for a number of nontraditional fields for women. Figure 2 shows national patterns in the percentage of degrees granted to women over the past decade in medicine, law, veterinary medicine, and dentistry. While the curves start at different points, they all begin their steepest increases in 1973 and 1974. Furthermore, as in engineering, once sharp increases begin, they follow somewhat parallel courses. These data suggest that the early seventies saw a shift in social attitudes that permitted women to consider a variety of nontraditional fields. The enactment by Congress in 1972 of Title IX prohibited sex-based discrimination in undergraduate programs regarding admissions policies and practices, housing, facilities, access to course offerings, counseling, financial aid, athletics, and such. Title IX and other antidiscrimination laws and associated regulations adopted in the seventies at both the federal and state levels to curb discrimination affirmed shifts in societal attitudes that made women feel freer to pursue education in fields from which they long had been largely excluded. Our case studies indicate, however, that engineering schools responded more to the attitudinal shift, particularly its manifestation among engineering employers, than to legal mandates. Title IX seldom

Figure 3

Selected Professional Degrees

(Percent of Women)

1969-1978



Source: U.S. Department of Health, Education, and Welfare, National Center for Educational Statistics. Table compiled by University of Washington Affirmative Action Office for Women.

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was mentioned on these campuses as a factor in increasing enrollments; indeed, reference to coercive forces of any sort was scarce.

Paradoxically, downward changes in the engineering job market during the early seventies improved the likelihood that women would be favorably greeted as students in engineering schools. Because of the downturn, overall enrollments in engineering schools steadily decreased from 1970 to 1973, both nationally and in our case-study schools. Where faculty slots were tied to FTE student enrollments, engineering schools naturally took an interest in finding new sources of applicants. Women, who were starting to consider nontraditional fields and who otherwise shared characteristics with male engineering students, provided a relatively untapped pool of applicants. Thus college faculties had incentive not to discourage the enrollment of women--and, as illustrated in each of our case studies, many institutions did much more to actively recruit women students.

In the labor market, the fate of engineering-related industries contributed to the pattern of events enabling greater numbers of women to enter schools of engineering. Two factors directly affected industry: (1) the enforcement of federal laws and regulations about affirmative action and equal opportunity, and (2) changing economic and technological trends, which brought about a decrease in engineering employment opportunities during the late sixties and early seventies and increasing employment opportunities from the mid-seventies on. Since the earliest affirmative-action regulations did not apply to women in higher education, the focus of government enforcement primarily affected industries with government contracts, and these industries usually employed large numbers of engineers. Industry, therefore, was actively responding to government efforts before affirmative action became a matter of concern in colleges and universities. By the early seventies, industry had created a demand for women engineers far beyond the supply engineering schools could provide. We observed earlier that schools of engineering tend to be fairly tightly coupled with industry, so the demand for women engineers was likely to be quickly communicated. Furthermore, it was to industry's advantage to provide financial support for schools to recruit women and to initiate programs in elementary and secondary schools to increase the supply of high-school graduates with strong math and science backgrounds. In turn, this support allowed institutions to initiate new programs without having to draw resources from existing programs, which decreased the likelihood that programs related to women would appear threatening to faculty or men students.

The upsurge in demand for engineers in the mid-seventies allowed recruitment of women and minority engineers without employers having to drop existing staff or limit the hiring of white men. Research by Freeman (1976) indicates that engineering is a field in which enrollments are extremely sensitive to the labor market. In the case studies, the effect of a promising job market for women was repeatedly cited as a factor influencing the enrollment of women in engineering.

At the national level, increasing concern for diminishing natural resources likely was one of the developments encouraging higher enrollments of women in engineering. Several of those interviewed noted that the image of engineering as a profession declined in the

1960s, when technology was widely regarded as the source of many social ills. In the 1970s, however, the image (and substance) of engineering shifted as technology came to be viewed as a solution to environmental problems. Curricula were expanded to encompass such areas as transportation and urban systems planning, social management of technology, and bioengineering. Brochures from colleges of engineering spoke of the field in terms of its relevance to social change. These shifts had the effect of extending the image of engineering into domains of traditionally greater interest to women than pure technology. At the same time, the interests of women were shifting to areas previously considered inappropriate for them. These patterns are reflected in our cases, with more women going into engineering but focusing on areas likely to be associated with social and environmental concerns, such as civil, chemical, and industrial engineering.

9. SOME OBSERVATIONS AND SPECULATIONS ABOUT THE FUTURE FOR WOMEN IN ENGINEERING

The contributors to this report who were involved in developing the case studies accumulated a host of impressions that are too subjective to offer as documentation for specific attitudes, intentions, or perceptions of the individuals interviewed or their schools. But taken together and combined with some a priori conclusions about the experience of the seventies, these impressions provide a basis for a few speculations that may be worth the consideration of those interested in further improvement in the participation of women in engineering education.

The Question of Parity

We do not know what level of enrollment of women in engineering education, or what distribution of that enrollment among institutions or among fields within a given engineering program, would signal the achievement of fully equal opportunity. What we see over the past decade is a good indication that women's enrollments may well approach, reach, or even exceed numerical parity with men's enrollments in at least a few institutions. Whether the upward national trend of the seventies will continue at the same rate of increase through the eighties is problematical, for several reasons.

First, all available studies indicate that most women entering engineering programs have been at least a thin cut above the typical male entrant in terms of academic ability and at least his equal in determination, energy, perseverance, and acuity. By and large, women in engineering programs are the sort most likely to go to college, to choose demanding programs, and to look to professional or academic careers. We could obtain no data allowing us to compare the male and female application pools at the case-study institutions. We either were told, or sensed, though, that the women's pools are usually much smaller but have a larger proportion of students of high ability. As the number of women applicants approaches parity, however, the distribution of ability within the women's pool almost certainly will come to more nearly approximate that of the male pool--as should academic performance in engineering programs.

The expectation generally expressed at the case-study schools is that such a leveling off will not engender difficulties for women students or arouse latent resistance to them once they no longer excel academically as a group. But that expectation has little empirical basis. It is true that the present tendency among administrators, faculty, and support staff alike, as well as both men and women students, seems to be to regularize the presence of women students: campus chapters of the Society of Women Engineers do not appear to thrive for long; the absence of women faculty to serve as role models is at most a minor issue among women students; women students are prominently involved in the established academic and professional student organizations and are taking perhaps more than their share of academic honors; today's women students in engineering seem in all important respects well suited to succeed by male standards, not particularly in need of psychological or social support, and understandably pleased with their success and the success of their sister students. In short, women engineering students are looked up to on the campus today.

Whether all that will hold true for women who have less academic ability, and thus will be more likely to fail or perform marginally, remains to be seen. Whether women who have no competitive edge over men will find all the academic, psychological, and social support they need and want also is a matter for speculation. One may even wonder at what the attitude of high-ability women will be toward less gifted women students, especially if the presence of the latter tends to dim the present bright image of the former.

Volatility of External Forces

We have argued that external forces mainly account for the increase in women's enrollments in the seventies, with the institutions playing a facilitative role for the most part. We also have noted that engineering enrollments are especially sensitive to employment trends. Administrators of engineering schools seem unanimously convinced that the nation's need for engineers (a need not always fully reflected in the job market) well exceeds the production of graduates. In any case, women graduates seeking employment as engineers today are virtually assured of desirable, well-paid positions. But if the employment picture for engineers should worsen, for whatever reasons, women engineers might suffer heavily from the first-in, first-out retrenchment practices common in American business and industry.

Our strong impression is that the single most important factor in motivating women to study engineering today is the excellent prospect for professional employment at a good salary. If this prospect should diminish, the effect on women's enrollments might be disproportionately strong. Engineering schools might forestall such a development by finding ways to persuade prospective women students that despite occasional short-term downturns, the long-range employment prospect for all engineers is sound. More than once, we heard the notion that when women's enrollments reach a critical mass--say 25 percent--they become self-sustaining. The metaphor is appealing, but it has the weakness inherent in all arguments by analogy. And even if substantially true, the critical-mass thesis logically implies that when enrollments of women drop below a certain point, the environment becomes less supportive for women.

The dual possibility of a deterioration in employment prospects and consequent deterioration in the supportive quality of the campus environment for women engineering students suggests that engineering schools should seek to exert more influence on the world around them. They might become a stronger shaping force on the secondary-school environment from which they recruit women students. They might also try to convince the professional engineering world that the progress they together have achieved regarding women's participation in the seventies should not be vitiated by short-term volatility in the job market. For example, women engineers might be retained on the basis of merit rather than length of service when cutbacks must be made, so that a fair presence of women is maintained.

Parity or Plateau?

In talking with researchers who have studied women in engineering, we heard more than once the view that women's enrollments may already be leveling out, and in any case will soon reach a plateau. This belief reflects concern that engineering firms are shifting their attention and education support away from women in favor of minorities, and an expectation that the engineering schools will either have to follow suit or lose some industry support. The national data do not at present indicate that a plateau has been reached, either in enrollments or placements of women. But the case studies developed for this report do not involve typical institutions, and the future for women in these institutions may well be distinctly different from that experienced in the great bulk of schools. Sixteen percent participation nationally represents a significant gain in a decade, but it falls considerably short of the parity enrollments of women generally in higher education. The present study, like most concerned with women in engineering, sheds little light on normative practice, typical attitudes, and average experience with respect to women engineering students in the nation's 486 engineering colleges and schools.

The Federal Role

The terms affirmative action, equal opportunity, and equity were seldom used in our interviews and informal conversations at the case-study institutions. Title IX was never identified as a factor prompting institutional efforts to increase the enrollment of women. Federal pressure was identified as a cause for industry to support recruitment of women students and to employ them when they took their degrees, but not acknowledged as an influence on institutional behavior. No such reserve is evident when industry pressure is discussed; indeed, the needs and wishes of industry are freely acknowledged as influences. We believe this is so because industry has been willing to commit resources to help engineering schools recruit women and retain them. Federal funds often will be part of the financial-aid package, of course, but BEOG and similar grants are available to men and women students on an equal basis. The general diffidence with respect to federal legislation and other initiatives to promote equal opportunity for women students will not surprise anyone conversant with the feelings of college and university administrators today. The federal government is often seen as bent on coercion more than cooperation and support--by contrast, in the instance of engineering schools, with the posture of employers.

Yet in the coming decade, it may be in the best interest of the institutions as well as the federal government to establish rapport and work together to offset the possible negative impact of employment trends or changed attitudes regarding women engineers. Federal agencies concerned about equal opportunity in higher education might do well to consider ways of changing the federal image on campus. One approach might be to have federal personnel become more knowledgeable about the traditions, conventions, and decision processes in higher education and also acquaint themselves with the facts about the resources pinch on most campuses. In most instances, Paul cannot be paid without robbing Peter, and academic executives have little stomach for such fiscal tactics. They are more inclined to respond to incentives than to what they regard as coercion and would rather cooperate than comply.

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This annual report surveys well-known businesses and industries to provide information about the employment of college graduates in business. Most corporations studied are large or medium-sized and regularly recruit college men and women. Employment trends are given as well as fields of greatest demand. Starting salaries are provided by field and sex. Includes a summary and employment trends of college graduates.

Kanter, Rosabeth Moss. Men and Women of the Corporation. New York: Basic Books, 1977.

In the chapters most relevant to this study, Kanter discusses her research on a large industrial corporation specifically as it relates to the effects of relative proportions of social groups. She considers the behaviors that are common to people in a corporate setting in which they are a social minority by virtue of race, sex, political values, and so forth. She observes that they tend to feel singled out, conscious of being observed, tend to maintain a low profile, and feel responsible to "do better." In turn, co-workers are more likely to stereotype the person in a minority situation. Kanter develops these observations into a more general theoretical framework.

Scientific Manpower Commission. Scientific, Engineering, Technical Manpower Comments.

This monthly publication provides information about the supply and demand of professionals in scientific, engineering, or technical fields. Includes information about research projects, publications of interest, and pending federal legislation and budgets.

Stashower, Gloria. Have You Considered Engineering? Opportunities for Women Are Expanding. Career Options Series for Undergraduate Women. New York: Catalyst, 1976: Arlington, Va.: ERIC Document Reproduction Service, ED 127 451.

This booklet, part of a set of self-guidance publications prepared by Catalyst, a national nonprofit organization, is written specifically for undergraduate women to help them bring their aspirations into focus, develop realistic career goals, and plan for career options in fields that, at the managerial and professional levels, have been traditionally male-dominated. The booklet covers (1) the spectrum of positions within the field of engineering, (2) educational requirements, and (3) the employment outlook during the next decade. Interviews with people who have achieved success in the field are also included. The booklet addresses other issues facing young women today, such as the right to make independent choices and to gain autonomy and the importance of informed and imaginative planning.

Vetter, Betty M.; Babro, Eleanor L.; and McIntire, Judith E. Professional Women and Minorities: A Manpower Data Resource Service. Washington, D.C.: Scientific Manpower Commission, 1978.

This document was prepared to assist people or groups seeking data on the participation and availability of women and minorities, or both, in professional areas generally requiring formal education at least to the baccalaureate level. It is a compilation of data from over 200 published and unpublished sources, including reports and materials from government agencies, professional associations, and women's or minority groups and caucuses. The source for each table is given, in addition to a full bibliographic entry.

Because the data are gathered from numerous sources and different methods of analysis are utilized, exact correlation of results is not possible. Although the book does not attempt to determine which results are most likely to be correct when differences occur, it does provide information about the population base. Its value lies in the breadth of information given about enrollments and the degrees of categorical breakdown of men, women, and minorities in specific professional and nonprofessional fields. In order to measure progress and changing trend lines for planning projections, data are also provided about general professional areas and general work-force and academic work-force participation.

II. Women High-School Students: Awareness and Preparation

Armstrong, Jane, and Kahl, Stuart. "An Overview of Factors Affecting Women's Participation in Mathematics." Paper prepared for the Women in Mathematics Project, National Assessment of Educational Progress, Denver, 1979.

In scope and design, this study is a close examination of the societal, cultural, and educational factors that affect the tendency of girls to take less mathematics in high school than boys. It attempts to provide a broad understanding of the problem, its complexity, and the interrelationship of many possible causes--in particular, the relative importance of factors identified in the literature as affecting the particpation of young women in mathematics. To this end, a survey questionnaire was developed and administered to a national sample of 13-year-olds and high-school seniors (male and female). Affective, cognitive, and background variables were measured.

The emphasis of the study was to determine which variables correlated with mathematics participation. For both sexes, a high correlation was found between confidence in math, anxiety over math, enjoyment of math, and perceived usefulness of math with course-taking. One of the study's recommendations is to better understand the relationship of variables within a group rather than to make comparisons between groups.

For the study, "participation" was defined as the math level in which a student was engaged. From the twelfth-grade sample, attitudes toward mathematics, career and academic aspirations, and the influence of parents and teachers appeared to affect participation. This study did not support the findings of prior research that mathematics is a stereotyped male domain or that peer influence substantially affects women's decisions to take high-school math. The different findings may be explained by changing attitudes, but more research is needed. A major intervention strategy suggested is to encourage parents and teachers actively to support youth in taking more math and relating course work in the subject to educational and career goals.

Fox, Lynn H. "The Effects of Sex-role Socialization on Mathematics Participation and Achievement." Paper prepared for the National Institute of Education, U.S. Department of Health, Education, and Welfare, Washington, D.C., December 1976.

This extensive literature review examines the effects of sex-role socialization on participation and achievement in mathematics. Its focus was on understanding the factors related to sex differences in mathematics achievement, with particular attention to course-taking.

A few factors that appeared to relate directly to sex differences in course-taking were the perception of the usefulness of mathematics for careers and the support and encouragement of significant others. The research indicated that peers, teachers, and counselors were more likely to reinforce attitudes than to change attitudes already shaped by the home and society at large. Parents appear to play a crucial role in the formation of attitudes and career interests in mathematics.

A third factor that emerged within the literature but about which there is less direct research evidence is the influence of the institution's educational policy and practice. A major barrier to more rapidly increasing enrollment appears to be the lack of career education and counseling programs at elementary, secondary, and postsecondary levels.

Underlying these factors is the perception that math is a male domain that emerges from media, textbooks, and tests. There is also evidence that females perform more comfortably in tasks perceived as feminine or neutral than those labeled masculine. The sex-role stereotyping of mathematics as masculine also leads to different expectations about performance within math classes for boys and girls and elicits different teacher-student responses. The paper is broken down into the following sections: Perceptions of the Career Relevance of Mathematics; The Influence of Signficant Others; The Perception of Mathematics as a Male Domain; Attitudes, Self-confidence, and Values; Educational Policies and Practices; and Conclusions and Recommendations.

Liebman, Judith. "Women in Engineering at the University of Illinois in Urbana-Champaign." IEEE Transactions on Education E-18 (February 1975): 47-49.

The participation of women as students and as faculty members in the College of Engineering at the University of Illinois in Urbana-Champaign is examined in this paper. The enrollment of undergraduate women and the engineering degrees awarded to them is compared with national averages. Recent efforts by the University of Illinois to attract more women into the engineering curriculum has resulted in extensive and creative programs designed to increase the enrollment of women. Two of the activities have included the sponsorship of a two-day conference to introduce young high-school women to engineering and professionals in engineering within higher education, government, and industry. A guidance brochure, Engineering Add-Lib, has won a college publication award. Finally, the low frequency of women on the university's teaching faculty in engineering departments is noted, and some of the factors that have worked against the hiring of women engineers for faculty positions are discussed.

Medalen, Joyce. "Women in Engineering: 1 Percent to 10 Percent in Four Years." IEEE Transactions on Education E-18 (February 1975): 8-40.

Special programs that lead high-school students to register as freshman engineering students are relatively new to most universities. The enthusiasm and support of the College of Engineering at the University of North Dakota is evident by summer programs that have been conducted for young high-school women over the past four years. Enrollment has been up 10 percent during this time. Fifty percent of all female engineering students are summer-institute participants. The other 50 percent have enrolled directly in the college or transferred from other institutions or disciplines. Although there continues to be no female engineering faculty, a sizable group of women students is now enrolled in the engineering program, and support from the administration and staff continues--encouraged by the talent and qualifications of women entering the program.

Several facts learned from the first experience are that (1) many talented young women can be encouraged to consider engineering as a profession; (2) few high-school counselors or teachers encourage female students to consider engineering; (3) few engineers can clearly define to high-school students what they do; (4) a program presented to high-school students must have a dynamic, vigorous staff; (5) visiting practicing female engineers who can interact with the young women are an invaluable asset; (6) the students want lab experience; and (7) considerable comradery to provide continued support can be established in a short time when there is a common purpose.

Sells, Lucy. "The Mathematics Filter and the Education of Women and Minorities." Paper presented at the annual meeting of the American Association for the Advancement of Science, Boston, 18-24 February 1976.

This paper discusses how the level of high-school mathematics participation acts as a critical filter in keeping women from free choice among undergraduate majors and limits students' work-world opportunity. Not only do high schools vary in the amount of math preparation they require or recommend, but college and university requirements also differ.

From the results of a questionnaire presented to social-service students at the University of California in 1973, Sells draws the following conclusions. Boys and girls make different mathematics choices for a variety of reasons. One factor may be the possible biological and psychological effects of puberty on mathematics achievement as well as different course tracking within schools for males and females. Some teachers and counselors have interpreted the phenomenon as proof of self-selection.

There appears to be evidence, however, of a correlation between social support and participation in advanced mathematics courses and a strong relationship between social support and performance in advanced mathematics. More information is needed about how to intervene constructively.

III. Women in Engineering Programs: Recruitment, Retention, and Placement

Connolly, Terry, and Porter, Alan L. The Recruitment and Retention of Women as Undergraduate Engineers. Atlanta: Georgia Institute of Technology, 1978.

The focus of the study was on individual engineering undergraduate programs and the role of the college administration in facilitating the entry of women into those programs.

Because women-oriented programs take a variety of forms and emphases at different schools, this study tested the extent to which two key underlying mechanisms affected the success or failure of these programs. The first, called the Decision Support Hypothesis, included the concept of support from important others about the "high uncertainty" choice to be made by women considering entrance into a technical field. The second, called the Positive Feedback Hypothesis, included the formation of social and academic support groups on-campus, an effort to reach a "critical mass" of women within the school, and attitudinal change among high-school and college faculty and counselors.

The study design included a cross-sectional survey of all engineering schools in the United States, a focused study of 60 "extreme case" engineering schools, and an in-depth study of one school (Georgia Tech) with a successful Women in Engineering (WIE) program. Mailed questionnaires and interviews were used for the in-depth study.

Topics discussed within the report include: the current educational status of women in engineering, comparison of female enrollments to size of institution, activities of WIE programs, and recommendations for other WIE support activities.

Davis, Sandra. "A Researcher's-Eye View: Women Students, Technical Majors, and Retention." IEEE Transactions on Education E-18 (February 1975): 25-29.

This study used as its sample all women who entered the University of Minnesota's Institute of Technology between 1961 and 1970. A male comparison sample with academic ability and achievement levels equivalent to those of the women was also selected. This gave a sample size of 468 subjects who were followed up in October 1971 to determine whether they had graduated, withdrawn, or were still enrolled in the Institute of Technology. Data gathered included pre-entrance interest, ability, and personality measures; persistence records in the Institute; and response to a questionnaire returned by 70 percent of all subjects.

The data analysis in Phase One showed the women to be a high-ability group with higher achievement in mathematics and the sciences than in English and the social studies. They also appeared to have made their career decisions early, often during junior high school. In comparison to the men, their interests were broader. Both the men and women agreed that the stereotype of a coed in a technical major is a negative one.

Phase Two of the analyses revealed that 30 percent of the women compared to 50 percent of the men persisted. For those women in engineering, two of every three dropped out and left the area of technology completely. A factor in the women's higher withdrawal rate is the perceived inflexibility of the curriculum to include their broader interests. There appeared to be no relationship between the negative attitudes of others or the discomfort experienced with a minority position and persistence or nonpersistence in the program.

Several patterns emerged for women who dropped out with below-average grades. In the first pattern, grades were lower than students had anticipated, which affected their self-confidence. The second pattern indicated that students' neutrality in the choice of school and major when they entered work against their staying in the Institute.

Phase Three focused on women in engineering specifically. Although results were based on a small group, several themes emerged. Each of these students' fathers was employed in an occupation dealing with things rather than with people. Parental encouragement or support from key individuals appeared as an important factor in their continuing in an engineering major.

________. "Academic Experiences of Engineering Students: Does Sex Make a Difference?" Report prepared for the Interuniversity Research Group on Women in Engineering, University of Minnesota, September 1977.

The focus of this research initiated by the interuniversity Research Group on Women in Engineering was to examine whether or not men and women students in engineering have different college expeiences. Using a semistructured individual interview, seven participating institutions questioned 71 male and 102 female engineering students. In addition, a smaller group of students was interviewed who had entered engineering in 1972 and had subsequently withdrawn.

The ability and achievement data found that women had a slightly higher mean SAT-Verbal score and grade point average than did the men, although the differences were not significant. Men and women appeared to be similar in their reasons for persisting in engineering. They saw themselves as similar to engineers in terms of interests and abilities, and they valued student-support programs in the academic departments.

Both sexes were similar in having considered leaving the engineering program at some point. Women were more likely than men to mention situational obstacles, social pressure, or absence of support as reasons for leaving. They viewed support and encouragement from others as a reason for persisting and felt a woman's success depends on special qualities and characteristics above her interest in engineering.

Dresselhaus, Mildred. "Some Personal Views on Engineering Education for Women." IEEE Transactions on Education E-18 (February 1975): 30-34.

As the number of women becomes a significant component of the student body in engineering schools, engineering educators need to consider ways by which students will receive the best possible training, both in technical and professional areas. As a former student and now professor of electrical engineering at the M.I.T. School of Engineering, Dresselhaus discusses a range of issues relevant to the problems engineering women face.

One concern is that of isolation--either in a class, research laboratory, or an industrial or professional context. Minority status and greater visibility often conspire to reduce women's self-confidence and self-image. Women engineering students tend to have more doubt about their careers at every level of their professional development. The self-image problem is also affected by a tendency of male professors and students not to take women engineers seriously. Closely related to underrepresentation is a feeling of being "left out of the action." Social and tactical obstacles affect the establishment of interactive study relationships with male peers. Practicing female engineers feel outside of the "buddy" system, which has an adverse effect on promotion or advancement into managerial responsibility.

The program emphasis should be on training good engineers. As most entering students who are women have had less experience than men with laboratory skills, Dresselhaus teaches a basic lab course that also enables her to provide personal counseling and serve as a role model.

The adjustment to graduate school may be accentuated by choices women are having to make about marriage and childbearing.

Durchholz, Patricia. "The Hidden Career: How Students Choose Engineering." Engineering Education 70 (April 1979): 718-22.

From survey questionnaires and personal interviews, Durchholz identified factors that her research indicates are career-choice filters, which precede the choice of engineering. Overall, she found male and female engineering students to be similar in background and interests. Both sexes demonstrate a high degree of competency in academic skills, particularly in mathematics and sciences, and a desire to spend considerable time in other interests and types of recreation that require group participation.

Some significant differenes between the sexes emerged, however, in that women were more likely than men to need to come in contact with engineers.

Parents, high-school math or science teachers, counselors, or representatives from the industry were influential in helping women choose engineering as a field to pursue.

Other career-choice filters that preceded the choice of engingeering as a field were the perception of engineering as a field of opportunity and the student's enjoyment of problem-solving. However, the students interviewed entered engineering school with little or no idea of the work an engineer does.

Freeman, Richard B., ed. The Overeducated American. New York: Academic Books, 1976.

This book asserts that the U.S. has entered an era in which the college degree cannot be assumed to be a safe avenue to economic success. Discussions focus on the new depression for college-educated workers, a proposed model of how the college labor market operates, and reasons for the depression to that market during the seventies. One section of the book looks at how the labor-market changes affected blacks and women. Supporting statistics are cited and a bibliography is included.

Gardner, Robert. "Women in Engineering: The Impact of Attitudinal Differences on Educational Institutions." Engineering Education 67 (December 1976): 233-40.

For the 1974-75 academic year, the College of Engineering at Cornell admitted 648 students. All females and a randomly selected sample of males were asked to participate in an attitudinal survey; 81 males and 59 females responded. The principal objective was to determine if attitudinal differences occurred with different groups. Analysis by Mary Diederich Ott established attitudinal differences in six categories: academic backgrounds; attitudes and expectations; extracurricular activities and cultural interests; field choice, work attitudes, and academic goals; family background and family dependence; peer dependence; and marriage-career preferences.

A second objective was to gain insight into the impact of the institution on the attitudes of women. Data indicated that over the course of the year the women began to adopt the attitudes of the majority of their male peers with interest in above-average income, being creative and original, and working with people. This pattern reflects the views of the institution as it responds to the pattern of professionals who answered the same question.

The principal findings were that no significant differences emerged in the academic achievement or total attrition levels of the two groups over a two-year period. For women, their expecttions and satisfaction with academic achievement did decline as did their anticipation concerning future rewards of the profession. The difference that emerged in the field-selection patterns of the two groups at the end of the two years indicated neither group was more prepared or astute in selecting a field before entering.

In the longitudinal study, there is no evidence that the differences in attitudes, expectations, or interests of the students had any impact on the institution as measured by academic performance, attrition, or field selection.

Gardner then compared findings of other studies with those at Cornell. The factor of support, or the perception of support, at Cornell, through special programs and a large number of peers, appears to have accounted for dissimilar results from several other studies. Arriving at a "critical mass" of women students may provide the support required for improved retention of female students.

Lantz, Alma; Elliott, Linda; and Fox, Louise. Critical Mass and Social Support for Women Choosing Nontraditional Careers. Washington, D.C.: National Institute of Education, 1979.

The study compared the perceptions of the social environment of satisfied men engineering students against dissatisfied students and former students at 12 engineering schools. The results found no direct effects of the perceived or actual proportion of female enrollment on satisfaction with engineering. The proportion of females did not directly affect grade point average, feelings of social ambiguity and isolation, or perceived support from institutional personnel.

The proportion of females in the environment was strongly related to peer-group interactions. Relations among the percentage of women and presence of a confidant, feelings of social integration, and satisfaction with engineering were observed. Perceived support from the male peer group was consistently and strongly related to all measures of satisfaction.

The findings suggested (1) the inseparability between grades and social satisfaction, (2) the importance of the dominant male peer group and the family, and (3) the perception of alternative social situations. Within this study, no direct relationship was observed between the percentage of women students and women students' feelings of social isolation; many women expressed the importance of having a peer confidant or close friend at the school.

Two theories, "critical mass" and tokenism, addressed the direct effects of the structure of the environment on the individual. (Critical mass may be a precondition that leads to retention and satisfaction.) Two other theories, social support and individual-environment fit, emphasized the interplay between the individual and the social and structural aspects of the environment. The latter theory implies the environmental "fit" provides increased opportunities for forming close personal contacts and reduces the prospects for social isolation. The family, male or female close friends within the school, and school personnel were identified as important sources of social support for women in engineering.

LeBold, William K.; Butler, Blaine R.; Blalock, Marion; Knigga, E. Marie; Smith, Christine; Heckert, Bonnie; and Schillinger, John A. Putting It All Together: A Model Program for Women Entering Engineering. West Lafayette, Ind.: Purdue University, 1979: Arlington, Va.: ERIC Document Reproduction Service, ED 168 415.

A model career-preparation program for first-year engineering women at Purdue University is described. Key elements of this project, which is funded through the Women's Educational Equity Act, are (1) a course designed to provide engineering and career information and practical experience, (2) a means of evaluating the methods and results, (3) wide dissemination of all useful information generated by the experimental course, and (4) the collection of information relevant to programs for women in engineering. The program includes lecture-discussions of contemporary problems in the field by role-model lecturers, career-planning and counseling sessions, and laboratory experiences broadly related to the field of engineering. The first experimental course was evaluated by pre-testing and post-testing with standardized tests and specially constructed surveys relating to educational goals and self-concepts of students. The pilot course was revised and offered again as a set of three modules to provide more flexibility to meet student needs. Test results for both years (1977 and 1978) are included.

One module involved career counseling and planning as the women students appeared less certain about career choices. The career-planning activity packets were to increase the students' awareness of abilities and interests and provide information about career opportunities, particularly in the field of engineering. The students were then to develop a plan of action.

Another module was a laboratory course to give women students the opportunity to become familiar with tools and mechanical or technical tasks. The projects were designed to be applied to course work, experimental work within the semester, or work within private industry. This course arose from the fact that many women engineers enter fields of science or engineering with less confidence in their technical and mechanical abilities than do men who enter engineering.

Finally, the lecture-discussions were broadened to include technical report writing and preliminary study design. This course, using role-model lectures, brought together a diversity of people to discuss the relationships between engineering and societal problems. Results indicate the women in the experimental group gained considerably in technical knowledge compared with the control group: the highest retention rates also occurred among those women students who were in the 1977 experimental group.

Information dissemination about the program has included a slide-tape set about the model program and experimental course, conference papers, professional journal articles, an Associated Press news story, and public-service television spots. A brief annotated bibliography focusing on pre-college backgrounds and college and post-college development of women in engineering is presented, and comments from two students are included.

Nemeth, Susan E. "Women at General Motors Institute." IEEE Transaction in Education E-18 (February 1975): 36-37.

General Motors Institute (GMI) remained an all-male educational institution until 1965. Now it has the second largest female enrollment in any engineering school in Michigan.

Although the co-op program extends over a five-year period, the student becomes acquainted with a variety of jobs within the General Motors plants. Findings from a questionnaire distributed among some of the women indicate that many selected General Motors Institute because of the financial independence it provided. GMI also provided the opportunity for on-the-job experience while attending school.

GMI also has a pre-engineering and management program for students with engineering and management potential but who lack some prerequisites for direct admission into the program. Many participants in this one-year program are female and minority students.

Both men and women students in engineering appeared to have selected a technically oriented career due to the challenge of and their interests in math and science. Women seemed also to choose this field for the opportunity of a well-paying job and good prospects for advancement after graduation. Many women reported that relatives or friends encouraged them to enter the engineering profession.

Ott, Mary Diederich, and Reese, Nancy, eds. Women in Engineering--Beyond Recruitment, Proceedings of the Conference. Ithaca, N.Y.: Cornell University, 1975.

This comprehensive report contains invited papers and comments from a conference on the status and problems of women in engineering. Session 1 includes research on freshman engineers. The discussion of research reveals that most women (1) choose engineering as a field for college study late in their secondary education, (2) depend heavily on external sources of support, and (3) have attitudes and experiences different from male freshman engineers. Session 2 examines barriers to achievement--underrepresentation in class, lack of role models, male-oriented recruitment policies, and low salaries. Persistence and assertiveness are requisite for dealing with these problems. Session 3 explores the isolation, frustration, and sacrifices experienced by women entering a technical nontraditional field. Conflicts that arise in making career and life decisions are addressed. Laboratory and research skills are discussed in Session 4. A description of a basic lab-skills course at Cornell and a support program at Purdue to reduce attrition among women science students is presented. Career-choice implications and information systems available to women who are making career decisions are reviewed in Session 5. The two final sessions focus on experiences of women graduate-engineering students and the need for society to accept women among its new engineers. Although the conference addresses issues beyond those of recruitment, the final session examines the issue of recruiting processes that would inform women and minorities of possible career options within engineering.

Ott, Mary Diederich. Female Engineering Students: Attitudes, Characteristics, Expectations, Responses to Engineering Education. Final Report. Ithaca, N.Y.: Cornell University, 1978: Arlington, Va.: ERIC Document Reproduction Service, ED 160 400.

The major purpose of this study was to determine the characteristics and needs of new female engineering students and to develop or modify programs to meet their needs. The study surveyed 17 selected universities and colleges to identify characteristics and needs, both academic and nonacademic, of male and female entering engineering students, and to collect accurate enrollment and retention data for this sample. The nationwide sample included questionnaire surveys for members of the 1975 and 1976 freshman population and spring 1977 sophomore members.

Included in the study is (1) an overview; (2) comparison of the survey population with the population of the United States' university freshmen; and (3) a comparison of black women and white women who are engineering freshmen; (4) a summary of the survey results, and (5) policy implications for engineering colleges. Certain characteristics were also provided that distinguished the retention and nonretention groups within the sample.

The summary outlines some of the disparities between female and male engineering freshmen. Among the sample, women engineering students chose their major field somewhat later than did the men. Although the women had been superior high-school students, they expressed lower self-esteem than did the male respondents. The women were also more likely to consult with others about decisions. The study further described ways in which male and female freshman engineering students differed in their interests, types of activities pursued, and attitudes toward graduate study, work, and future careers and marriage.

Policy implications included the need for active recruitment of high-school students, including efforts to encourage females in the lower grades to continue mathematics courses. For female students in college engineering, there appeared to be the need to develop a peer-support base. A broader course base, an opportunity to develop positive attitudes toward laboratory work, and the desire for academic counseling and career guidance services emerged as needs expressed by women students.

________. "Retention of Men and Women Engineering Students." Research in Higher Education 9 (1978): 137-50.

After 1.5 years of college, men and women engineering students in a population of 42 schools had differing retention rates. Based on a sample of students at 16 schools in the 1975 fall term, the estimated population retention rates were 73.3 percent for men and 67.8 percent for women. This report discusses student characteristics that were related to retention for men or women, as well as the destination of students who left engineering at their original schools.

Student characteristics were determined by means of a survey. Characteristics were studied separately by sex and retention or nonretention in the original school.

Prior academic achievement and academic expectations were related to retention for both sexes. However, the academic standings of women indicated academic failure would be a less likely reason for women to leave the program than for men. Motivation was also a retention factor but operated differently for men and women. Parents' attitudes toward college attendance of the student was also a related factor. Self-confidence appeared to be related to retention for men but not for women. Those who were not retained (136 men and 155 women) reported several destinations. A majority of the women students wanted to transfer to another degree program within the institution. Some men also cited this as the main reason for leaving the engineering school. (The reasons for the program transfers within the institution were not determined.) Academic failure and dismissal directly affected more men than women students.

Rose, Claire, and others. The Study of Academic Employment and Graduate Enrollment Patterns and Trends of Women in Science and Engineering. Summary Report. Washington, D.C.: National Science Foundation, 1978.

A study was undertaken of the employment and enrollment patterns of women scientists and engineers and graduate students in eight major scientific fields: engineering, physical sciences, environmental sciences, mathematical sciences, agricultural and biological sciences, medical sciences, psychology, and social sciences. The first part of the study consisted of a series of statistical analyses of institutional and departmental patterns in women's full-time graduate enrollment and full-time employment in sciences and engineering in the 50 leading doctorate-granting institutions. The second phase consisted of case-study site visits to a sample of nine institutions selected in geographic location, urban and rural environment, institutional size, type of control, and proportion of women scientists employed. The case-study institutions were the University of Arizona, Harvard University, Louisiana State University (Baton Rouge), University of Michigan, Northwestern University, Purdue University, University of Southern California, Texas A & M University, and the University of Washington. The statistical analyses employed were designed to identify distinctive trends, to move beyond presentation of numbers and percentages, and to search for significant and distinctive differences. The report was descriptive and did not contain specific research hypotheses. The analyses and results are described and include some illustrations.

Several findings contradict the literature on professional women. For example, women scientists and engineers employed full-time were concentrated in the largest institutions. The present concentration in the top-level programs is possibly related to the fact that while the pool of applicants remain small within a discipline, the pool usually consists of outstanding women in ability and performance. Still, women scientists remain a small minority in the scientific community without much power or prestige.

In spite of increasing numbers of Ph.D.'s, the proportion of women scientists in full-time tenured positions has not increased significantly nor does the situation appear likely to change with retrenchment and tighter budgets. Viewing academe as students, most graduate students stop with a master's degree as there are better opportunities and salary potential for them in industry than in higher education.

Six variables were analyzed: size of institution, geographic location, resource of support, institutional orientation, research vs. teaching, and quality ranking of the department. None were found to be predictors of the number of women who would attend that particular program.

Sproule, Betty, and Mathis, Harold. "Recruiting and Keeping Women Engineering Students: An Agenda for Action." Paper presented at the annual meeting of the American Society for Engineering Education, June 1975; Engineering Education (April 1975): 745-48: Arlington, Va.: ERIC Document Reproduction Service, ED 118 383.

This paper presents a survey of the techniques used by 29 engineering colleges that have been successful in recruiting and retaining women engineering students. Among those techniques for increasing the enrollment of women engineering students are (1) make a commitment to increase the enrollments by allocating resources, funding, and faculty to recruit and counsel women students; (2) publicize the engineering program to prospective women students; (3) recruit prospective women students at the high-school level, which includes sending engineering students to help conduct workshops and talk with students at various high schools; (4) counsel women students after they arrive on campus; (5) establish a student section of the Society of Women Engineers; (6) hire women faculty and administrators; (7) recognize outstanding women students through professional memberships and other awards; and (8) publicize career opportunities for engineering graduates.

IV. Working Women: Engineers and Scientists

Bugliarello, George; Cardwell, Vivian; Salembier, Olive; and White, Winifred, eds. Women in Engineering: Bridging the Gap between Society and Technology. Chicago: Illinois University, 1971: Arlington, Va.: ERIC Document Reproduction Service, ED 086 070.

Under the sponsorship of the Engineering Foundation and the Co-sponsorship of the Society of Women Engineers, a conference on "Women in Engineering--Bridging the Gap between Technology and Society" was held. The conference's goal was to consider the extent to which a greater participation of women in technology can arrest the widening gap developing between technology and society and to propose a national strategy for increasing this participation. This document contains the addresses of invited speakers concerning various aspects of the problem as well as background information. The main thrust of the conference was carried out through action-oriented workshops. Workshop 1 addressed the problem of the gap between technology and society and the role of women in reducing it, and Workshop 2 considered women as engineers and their opportunities. These two workshops served as background primers. Workshops 3, 4, and 5 considered programs for the effective participation of women engineers in industry, government, and education, respectively. A sixth workshop was formed to pursue further the primary issue of women engineers' roles in bridging the gap between technology and society. In the summary an outline is given of workshop activities, including recommendations and resolutions. A selective bibliography and a post-conference newsletter are presented in the appendixes.

Crowley, Michael. Women and Minorities in Science and Engineering. Washington, D.C.: National Science Foundation, 1975: Arlington, Va.: ERIC Document Reproduction Service, ED 147 098.

This report was developed from existing statistical data to illuminate the role of women and minorities in science and engineering. Two issues are addressed: whether there is a problem related to the employment of women in these fields and whether women and minorities are underutilized in these fields. Sections of the first part of the report discuss the size of the science and engineering population and the amount of participation, employment data, unemployment rates, salaries, and conclusions. Relatively few women or minority scientists and engineers are unemployed, but the participation rate of female scientists and engineers is far below that of men in the work force.

The second section discusses utilization in terms of abilities, science majors, transition from school to work, trends, and conclusions. Data indicate (1) an under-utilization of women in the sciences and engineering, (2) the perception of engineering as a field with limited opportunities for women seems to have encouraged many science-talented women to enter traditional fields, and (3) those who did enter science or engineering professions were more likely than their male counterparts to work in the academic sector or the lower levels of the profession.

Lantz, Alma. "An Evaluation of Programs for Reentry Women Scientists." Paper presented for the National Science Foundation. Denver: Denver Research Institute, 1979. [The findings and conclusions, to be published by Westview Press, will be titled Reentry Programs for Female Scientists.]

This report focuses on research involving a series of projects called Career Facilitation Program, funded by the National Science Foundation. These projects are designed to assist women trained in science to update their skills for entry or reentry into the work world or to continue graduate education in science-related fields.

The Career Facilitation Program is aimed at women who received bachelor's or master's degrees in science at least two years ago and who are not presently employed in the fields for which they were trained. This project, started in 1976, has supported 21 projects.

The Science Career Facilitation projects have been of three types: one updates participants' skills in their original fields; a second helps participants make a transition from one field to another; and a third both updates participants knowledge in their fields and gives additional training in a new field (an equivalent to a special interdisciplinary degree).

An evaluation of the project found most women scientists not currently employed had left the labor force to care for families and were facing many of the same barriers to gain employment as other women attempting to reenter the labor market. Although there is the belief that organizations assist women reentering the work force, contacts with over 2,000 agencies and organizations reveal that not a single program or course addressed all the needs of women scientists who wanted to resume their careers.

Lantz reports there is a demand for the program due to the numbers within an eligible pool. Within the 21 projects, almost 65 percent of the participants were currently employed, some in internship or co-op programs with industry. The success of the projects indicated need for continuation.

Four basic intervention models were presented to assist women scientists: the retraining model, the refresher model, the career-advancement model, and the prevention model. Each model addresses a different target group and has different outcomes, incentives, and costs.

Vetter, Betty M. "Working Women Scientists and Engineers." Science 207 (January 1980): 28-34. [This article is a summary of a 14-month study entitled "Labor Force Participation of Women Trained in Science and Engineering and Factors Affecting Their Participation." Final Technical Report, 1979.]

The study sought to examine the factors that influence the participation of women scientists and engineers in the work force. The data analyzed included two National Science Foundation surveys, in 1976 and 1978, of recent bachelor's and master's graduates in science and engineering, and data from a 1975 survey by Solomon and others of graduates from the 1961 freshman class who, by 1971, had received no higher degree than a bachelor's in science or engineering fields.

The purpose of the study was to determine labor-force participation of women scientists and engineers and the factors affecting their participation. Factors were also examined that affected the retention or withdrawal of these women from the work force, as well as their patterns of career development including attainment of advanced degrees; the effect of their mental and parental status on their career advancement; and the utilization of their abilities in science and engineering. It was also possible to examine some of the problems women experienced in resuming their careers.

Although about 80 percent of the women trained in science or engineering are in the work force, many are employed outside their fields. Many leave the labor force temporarily. Women with science or engineering degrees are more likely than other women college graduates to be working even when they have children. This is especially true if the women have advanced degrees or are in fields with the opportunity for better-than-average salaries. Factors that affected labor-force participation are student status, highest degree level, parental status and age of children, and field of degree.

Women scientists and engineers still remain more likely to experience unemployment than men scientists and engineers, and women have lower earnings. A valid, less fragmented statistical base is needed for monitoring the progress and participation of women scientists and engineers. However, evidence remains that practices and policies of educational institutions, employers, and government agencies continue to act as barriers to women.